NPS-09-97-005

Naval Postgraduate School
Monterey, California 93943-5138
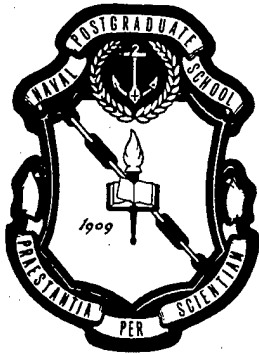
SUMMARY
OF
RESEARCH
1996

DTIC QUALITY INSPECTED 4

Department of Electrical and Computer Engineering

Herschel H. Loomis, Jr.
Chair

Jeffrey B. Knorr
Associate Chair for Research

19980223 013

Prepared for: Naval Postgraduate School
Monterey, CA 93943-5000

NAVAL POSTGRADUATE SCHOOL
Monterey, California
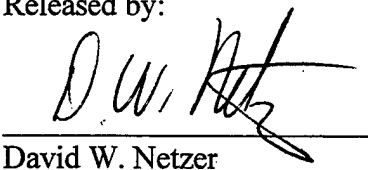
Rear Admiral M.J. Evans
Superintendent

R. Elster
Provost

This report was prepared for the Naval Postgraduate School, Monterey, CA.

Reproduction of all or part of this report is authorized.

Reviewed by:

Released by:

Danielle Kuska

D.W. Netzer

Danielle A. Kuska
Programs Supervisor
Research Office

David W. Netzer
Associate Provost and Dean of Research

REPORT DOCUMENTATION PAGE

Form approved
OMB No 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE November 1997	3. REPORT TYPE AND DATES COVERED Summary Report, 1 January 1996 - 31 December 1996

4. TITLE AND SUBTITLE
Summary of Research 1996, Department of Electrical and Computer Engineering

5. FUNDING

6. AUTHOR(S)

Faculty of the Department of Electrical and Computer Engineering, Naval Postgraduate School

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Naval Postgraduate School
Monterey, CA 93943-5000

8. PERFORMING ORGANIZATION REPORT NUMBER

NPS-09-97-005

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Naval Postgraduate School
Monterey, CA 93943-5000

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

The views expressed in this report are those of the authors and do not reflect the official policy or position of the Department of Defense or the U.S. Government.

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

A

13. ABSTRACT (Maximum 200 words.)

This report contains summaries of research projects in the Department of Electrical and Computer Engineering. A list of recent publications is also included which consists of conference presentations and publications, books, contributions to books, published journal papers, technical reports, and thesis abstracts.

14. SUBJECT TERMS

15. NUMBER OF PAGES
122

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

HERSCHEL H. LOOMIS, JR.
CHAIR

THE NAVAL POSTGRADUATE SCHOOL MISSION

The mission of the Naval Postgraduate School is to increase the combat effectiveness of US and Allied armed forces and enhance the security of the USA through advanced education and research programs focused on the technical, analytical, and managerial tools needed to confront defense-related challenges.

CONTENTS

Preface

Research is an integral part of graduate education. At the Naval Postgraduate School (NPS), the goals of research are to:

- Provide a meaningful, high quality, capstone learning experience for our students.

- Keep faculty on the leading edge of advances in defense-related science, technology, management and policy to ensure that the latest information is incorporated into NPS courses and curricula.

- Apply faculty and student knowledge to enhance DoN/DoD operational effectiveness.

Pursuit of these goals increases the technical and managerial capability of the officer corps to keep pace with an increasingly complex defense posture in today's world.

New technologies and policy changes will of course occur, necessitating changes in educational programs and stronger ties between the fleet and the support establishment. NPS must remain poised to face this challenge and to utilize emerging technologies and new policies within its curricula programs. Faculty, therefore, must stay abreast of these developments through a dynamic research program that helps fulfill the School's goals of excellence, uniqueness, and relevance.

The overall research program at NPS has three funded components. The Direct Funded Research and Institute for Joint Warfare Analysis Programs are institutionally funded within the School's operating budget. The Direct Funded Research Program is administered by the Associate Provost and Dean of Research. The Institute for Joint Warfare Analysis Program is administered by the Director of IJWA.

- The Direct Funded Research (DFR) Program provides funding to stimulate innovative research ideas of benefit to the DoN and may be used for cost-sharing with reimbursable research efforts. This funding ensures, in particular, that all Navy-sponsored NPS curricula are equitably supported, that new faculty are provided an opportunity to establish a research program of importance to DoN/DoD and other national security interests, and that faculty and students from across the campus are encouraged to interact with one another.

- The Institute for Joint Warfare Analysis Research Program provides funding to stimulate innovative research ideas with a strong emphasis on joint, interdisciplinary areas. This funding ensures that joint relevance is a consideration of faculty research.

- The Reimbursable Research (RR) Program includes those projects externally funded on the basis of proposals submitted to outside sponsors by the School's faculty. These funds allow the faculty to interact closely with RDT&E program managers and high-level policy makers throughout the Navy, DoD, and other government agencies as well as with the private sector in defense-related technologies. This ensures that NPS research remains highly regarded by academic peers and government officials and fosters a closer relationship between NPS and other outside organizations.

The three research programs are complementary and ensure that the overall research program is flexible, responsive, balanced and supportive of the unique needs of the military.

In 1996, the level of the research effort at the Naval Postgraduate School was 141 faculty workyears and exceeded 29 million dollars. Eighty percent of the research was funded by reimbursable sponsors and 20 percent was funded by the Naval Postgraduate School. Sixty-five percent of the work was performed for the Navy and the remainder was sponsored by other agencies, both DoD and non-DoD. A profile of the reimbursable program of the Department of Electrical and Computer Engineering is provided in Figure 1:
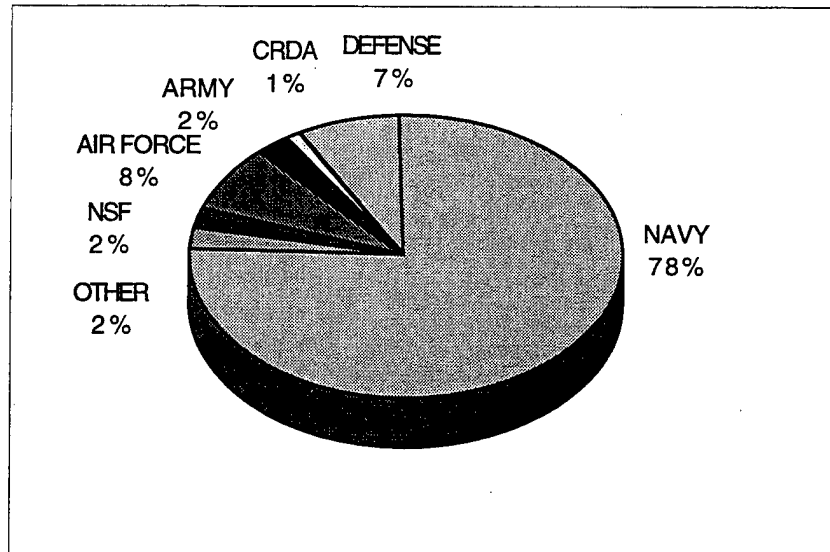
Size of Program: $2,871K

Figure 1. Department of Electrical and Computer Engineering- Sponsor Profile

Research at NPS is carried out by faculty in the School's eleven Academic Departments, four Interdisciplinary Groups and the School of Aviation Safety. In the pages that follow, research summaries are provided for projects undertaken by faculty in the Department of Electrical and Computer Engineering during 1996. An overview and faculty listing are provided as an introduction. A list of publications is also included, if applicable. Abstracts for thesis advisors by department faculty in 1996 complete this research summary.

Questions about particular projects may be directed to the Faculty Principal Investigator listed, the Department/ Group Chair, or the Department Associate Chair for Research. Questions may also be directed to the Research Office. General questions about the NPS Research Program should be directed to the Research Office at (408) 656-2098 (voice) or research@nps.navy.mil (e-mail).

August 1997

Loomis, Herschel H.
Professor and Chair
EC/Lm
408-656-2081 (phone)
408-656-2760 (fax)
loomis@nps.navy.mil

Knorr, Jeffrey B.
Professor and
Associate Chair for Research
EC/Ko
656-2815
jknorr@nps.navy.mil

Adler, Richard   .
Research Associate Professor
EC/Ab
656-2352
rwa@mcimail.com

Fouts, Douglas J.
Associate Professor
EC/Fs
656-2852
fouts@ece.nps.navy.mil

Jenn, David
Associate Professor
EC/Jn
656-2254
jenn@ece.nps.navy.mil

Ashton, Robert W.
Assistant Professor
EC/Ah
656-2928
ashton@ece.nps.navy.mil

Garcia, Vicente C., Jr.
SIGINT- Chair
EC/Ga
656-2110
vcgarcia@nps.navy.mil

Kragh, Frank E.
Research Assistant

LeBlanc, Jace
Visiting Instructor
EC/Lj
656-2390
leblanc@ece.nps.navy.mil

Bernstein, Raymond F.
Research Associate
EC/Be
656-2726
berstei@ece.nps.navy.mil

Gill, Gurnam S.
Senior Lecturer
EC/Gl
656-2652
gill@ece.nps.navy.mil

Lee, Chin-Hwa
Professor
EC/Le
656-2190
chlee@ece.nps.navy.mil

Butler, Jon T.
Professor
EC/Bu
656-3299
butler@ece.nps.navy.mil

Ha, Tri T.
Professor
EC/Ha
656-2788
ha@nps.navy.mil

Lee, Hung-Mou
Associate Professor
EC/Lh
656-2846 or 2030
hmlee@nps.navy.mil

Ciezki, John
Assistant Professor
EC/Cy
656-3001
ciezki@ece.nps.navy.mil

Hippenstiel, Ralph D.
Associate Professor
EC/Hi
656-2633
hippenst@ece.nps.navy.mil

Levien, Fred
Senior Lecturer
EC/Lv
656-2476
flevien@nps.navy.mil

Cristi, Roberto
Associate Professor
EC/Cx
656-2223
cristi@ece.nps.navy.mil

Hutchins, Robert
Associate Professor
EC/Hu
656-3289
hutchins@nps.navy.mil

Lott, Gus CDR
Assistant Professor
EC/Lt
656-3798
lott@ece.nps.navy.mil

Fargues, Monique P.
Associate Professor
EC/Fa
656-2859
fargues@ece.nps.navy.mil

Janaswamy, Ramakrishma
Associate Professor
EC/Js
656-3217
janaswam@ece.nps.navy.mil

McEachen, John C.
Assistant Professor
EC/
656-3652
mceachen@nps.navy.mil

Michael, Sherif
Associate Professor
EC/Mi
656-2252
michael@ece.nps.navy.mil

Moose, Paul H.
Associate Professor
EC/Me
656-2618
phmoose@nps.navy.mil

Morgan, Michael A.
Professor
EC/Mw
656-2677 or 3010
mmorgan@ece.nps.navy.mil

Pace, Phillip E.
Associate Professor
EC/Pc
656-3286
pace@ece.nps.navy.mil

Panholzer, Rudy
Professor
EC/Pz
656-2154/2278
rpanholze@ece.nps.navy.mil

Parker, Andrew A.
Instructor
656-2758

Pieper, Ron
Associate Professor
EC/Pr
656-2101
pieper@ece.nps.navy.mil

Powers, John
Professor
EC/Po
656-3411
jpowers@mntry.nps.navy.mil

Robertson, R. Clark
Professor
EC/Rc
656-2383
crobertson@nps.navy.mil

Schleher, D. Curtis
Professor
EC
656-3767

Shukla, Shridhar B.
Assistant Professor
EC/Sm
656-2764
shukla@ece.nps.navy.mil

Smith, Rasler W.
Visiting Professor
EC/Sr
656-2222
smithrw@nps.navy.mil

Terman, Frederick W.
Senior Leccturer
EC/Tz
656-2178
terman@ece.nps.navy.mil

Therrien, Charles W.
Professor
EC/Ti
656-3347
therrien@nps.navy.mil

Titus, Harold
Professor
EC/Ts
656-2560

Tummala, Murali
Professor
EC/Tu
656-2645
tummala@ece.nps.navy.mil

Vincent, Wilbur R.
Research Associate Professor
EC/Ab
656-2352
vincent@ece.nps.navy.mil

Wadsworth, Donald
Senior Lecturer
EC/Wd
656-2115/3456
dwadsworth@nps.navy.mil

Weatherford, Todd
Assistant Professor
EC/Wt
656-3044
weatherf@ece.nps.navy.mil

Wight, Randy
Research Instructor
EC/Wr
656-3403
rwight@nps.navy.mil

Yun, Xiaoping
Associate Professor
EC/Yx
656-2629
yun@nps.navy.mil

Ziomek, Lawrence J.
Professor
EC/Zm
656-3206
ziomek@ece.nps.navy.mil

DEPARTMENT SUMMARY

The research program of the Department of Electrical and Computer Engineering (ECE) is very broad, reflecting the variety of skills and interests of the faculty in providing technical advances and solutions to important problems for the Navy and the Department of Defense. DoD research in ECE is strongly coupled to instruction, both in bringing the most recent advances into the classroom and in providing highly relevant and unique thesis topics for officer students to investigate with faculty guidance.

Research in the Department of Electrical and Computer Engineering is supported by an internally funded research program called the Direct Funded Research (DFR) Program, and an externally funded research program called the Reimbursable Research (RR) program. The DFR program includes a Research Initiation Program (RIP) for new faculty and also provides funding for new initiatives, meritorious projects, cost sharing, and a postdoctoral program. The Reimbursable Research Program includes those projects which are externally supported by a wide range of government agencies, and by private industry through Cooperative Research and Development Agreements (CRADAs).

In FY 1996, ECE Department reimbursable research totaled $3.8M. A total of 14.5 faculty research work years were executed, representing 42% of the Department faculty labor. The Reimbursable Program supported 12.0 faculty work years, or 83% of the total research effort. The department's research work led to 17 journal papers, 45 conference presentations, 42 conference papers, 2 book chapters, 26 technical reports, and 1 patent application. These publications are listed following the Research Project Summaries.

Research projects in the department can be grouped into the following specialty areas: Communications; Computer Engineering; Electromagnetics; Power Systems; Infra-red and Electro-optics; Radar, Surveillance, and Information Warfare; Signal Processing/Underwater Acoustics; Guidance, Navigation, and Control; Microelectronics/VLSI/Radiation Effects; and Signals Intelligence/Space Systems. Following this introduction is a listing of 1996 research project titles and principal investigators, by specialty area. Although some projects span more than one area, they are listed in only one.

Complete Project Summaries appear following the specialty area listing. These Summaries appear in alphabetical order, according to the principal investigator's surname. Publications, presentations, and theses associated with each project are listed. The student thesis involvement in faculty research is evidence of the strong interaction between the department's teaching and research programs.

Communications

EXPLOITATION OF POTENTIAL JAMMING CAPABILITY OF ULTRA WIDEBAND SOURCE (UWBS)
    T.T. Ha, Professor

RF FREQUENCY AND POWER MANAGEMENT
    C-H. Lee, Professor

DIGITAL SPREAD SPECTRUM COMMUNICATION SYSTEMS
    R.C. Robertson, Professor

PREDISTORTION TECHNIQUES FOR HIGH POWER AMPLIFIERS
    M. Tummala, Professor

COMMUNICATIONS VULNERABILITY TO JAMMING
    D.v.Z. Wadsworth, Senior Lecturer

Computer Engineering

ADVANCED DIGITAL LOGIC DESIGN
    J.T. Butler, Professor

CONFERENCE INFORMATION SYSTEM
    M.P. Fargues, Associate Professor

Electromagnetics

SIGNAL-TO-NOISE ENHANCEMENT PROGRAM (SNEP) RESEARCH AND SUPPORT
    R.W. Adler, Senior Lecturer
    W.R. Vincent, Research Professor

ENHANCEMENTS FOR THE RF MISSION PLANNER
    R.W. Adler, Senior Lecturer

SYSTEM MODELING AND ANALYSIS CENTER SUPPORT FOR ANTENNA PERFORMANCE EVALUATION
    R.W. Adler, Senior Lecturer

FIELD STATION RESEARCH AND SUPPORT
    R.W. Adler, Senior Lecturer

EA6-B ANTENNA PERFORMANCE PREDICTIONS
    R.W. Adler, Senior Lecturer
    J.E. Lebaric, Visiting Associate Professor

MODELING RADIOWAVE PROPAGATION OVER TERRAIN AND ROUGH OCEAN SURFACE
    R. Janaswamy, Associate Professor

ELECTRO MAGNETIC SCATTERING FROM A TUBULAR CYLINDER OF ANISOTROPIC SURFACE IMPEDANCES
    H-M. Lee, Associate Professor

ELECTRO MAGNETIC SIGNATURE SOURCE MEASUREMENT USING SPATIAL SPECTRAL DOMAIN PROCESSING
    M.A. Morgan, Professor

IMPULSE ANTENNA DESIGN
    M.A. Morgan, Professor

ULTRA-WIDEBAND IMPULSE ANTENNA DESIGN
    M.A. Morgan, Professor
    R.C. Robertson, Professor

ULTRA-WIDEBAND IMPULSE SIGNAL PROPAGATION
    M.A. Morgan, Professor
    R.C. Robertson, Professor
    R. Janaswamy, Associate Professor

Power Systems

CONVERTER DESIGN, ANALYSIS, AND PROTOTYPE FOR FUTURE NAVY SURFACE SHIPS
    R.W. Ashton, Assistant Professor

THE DEVELOPMENT AND HARDWARE IMPLEMENTATION OF A PEBB-NETWORK SIMULATION TEST-BED
    R.W. Ashton, Assistant Professor
    J.G. Ciezki, Assistant Professor

LOW-POWER PEBB-ZERO HARDWARE ADAPTION AND DIGITAL CONTROL INTEGRATION
J.G. Ciezki, Assistant Professor

THE DEVELOPMENT AND HARDWARE IMPLEMENTATION OF A PEEB-NETWORK SIMULATION TEST-BED
J.G. Ciezki, Assistant Professor

DEVELOPMENT OF SIMULINK MODEL FOR UNMANNED AERIAL VEHICLE (UAV) ELECTRIC PROPULSION SIMULATION
J. Lebaric, Associate Professor

Infra-red and Electro-optics

LOW ALTITUDE INFRARED PROPAGATION ABOVE OCEAN
H-M. Lee, Associate Professor

HIGH RESOLUTION DIRECT DIGITIZATION AND OPTICAL TELEMETRY OF ANTENNA SIGNALS
P.E. Pace, Associate Professor

EXTENDING THE VISIBILITY MRTD MODEL TO SECOND GENERATION THERMAL IMAGING SYSTEMS
R.J. Pieper, Associate Professor

DUAL BASELINE TRIANGULATION
R.J. Pieper, Associate Professor
A. Cooper, Professor

DEVELOPMENT OF AN INFRARED PRESENCE SENSOR
X. Yun, Associate Professor

Radar, Surveillance, and Information Warfare

MISSILE CLOSURE SIMULATION AND ANALYSIS TO SUPPORT TESTING MISSILE APPROACH WARNING SYSTEMS
R.G. Hutchins, Associate Professor

EVALUATION AND EXTENSIONS OF THE PROBABILISTIC MULTI-HYPOTHESIS TRACKING ALGORITHM TO CLUTTERED ENVIRONMENTS
R.G. Hutchins, Associate Professor

NEAR-FIELD NEED-TO-CALIBRATE INDICATOR FOR SHIPBOARD HF ANTENNAS
D.C. Jenn, Associate Professor

SURVEILLANCE SYSTEM STUDIES
J.B. Knorr, Professor

ADVANCED PHASED ARRAY ANTENNA TECHNOLOGIES
C-H. Lee, Professor

PROJECT GUSTY ORIOLE
H.H. Loomis, Jr., Professor
RADM T.C. Betterton, USN (Ret)

M. Melich, Professor
F. Kragh, Research Assistant

CORRELATION OF ASCM SIMULATOR CAPTIVE-CARRY EXPERIMENTAL RESULTS
P.E. Pace, Associate Professor

AUTOMATIC EXTRACTION OF THREAT CRITICAL PARAMETERS FROM ASCM CHARACTERIZATION EXPERIMENTS
P.E. Pace, Associate Professor

BEARTRAP POST-MISSION ANALYSIS SYSTEM
M. Tummala, Professor

DATA FUSION ALGORITHMS FOR VESSEL TRAFFIC SYSTEM
M. Tummala, Professor

WIDEBAND SIGNAL ANALYSIS TECHNIQUES FOR ELECTROMAGNETIC TRANSIENT WAVEFORM ANALYSIS
M. Tummala, Professor

Guidance, Navigation, and Control

REAL TIME SENSOR BASED NAVIGATION AND CONTROL OF AUTONOMOUS UNDERWATER VEHICLES
R. Cristi, Associate Professor

LORAN-C: CALOC AND CASUALTY CONTROL
M. Tummala, Professor

DEVELOPMENT OF COOPERATIVE CONTROL ALGORITHMS FOR MULTI-ROBOT SYSTEM
X. Yun, Associate Professor

COORDINATION OF MOBILE MANIPULATORS
X. Yun, Associate Professor

CISE RESEARCH INSTRUMENTATION: EXPERIMENTAL STUDY OF MULTIPLE MOBILE MANIPULATORS
X. Yun, Associate Professor

DEVELOPMENT OF A SEMI-AUTONOMOUS ROBOTIC SYSTEM FOR MINE/UXO DETECTION AND CLEARING
X. Yun, Associate Professor

AN INTEGRATED INS/GPS SHALLOW-WATER AUV NAVIGATION SYSTEM
X. Yun, Associate Professor

Signal Processing/Underwater Acoustics

SIGNAL DENOISING USING WAVELET THRESHOLDING TECHNIQUES
M.P. Fargues, Associate Professor

DETECTION AND CLASSIFICATION OF TRANSIENT SIGNALS USING WAVELETS
M.P. Fargues, Associate Professor

PROCESSING OF SECOND ORDER STATISTICS VIA WAVELET TRANSFORMS
R. Hippenstiel, Associate Professor
M.P. Fargues, Associate Professor

WAVELET BASED TRANSMITTER IDENTIFICATION
R. Hippenstiel, Associate Professor

SONAR SIGNAL MODELING
C.W. Therrien, Professor

SUPPORT OF THE NEAR SHORE TACTICAL RECONNAISSANCE (NSTR) PROGRAM
L.J. Ziomek, Professor

MATHEMATICAL MODELING OF DOLPHIN BIOSONAR
L.J. Ziomek Professor

Signals Intelligence/Space Systems

SMALL SATELLITE DESIGN PROJECT
K.T. Alfriend, Navy TENCAP Chair Professor
H.H. Loomis, Jr., Professor

DIRECT BROADCASTING SYSTEM FOR THE MOBILE WARRIOR
P.H. Moose, Associate Professor

Microelectronics/VLSI/Radiation Effects

RADIATION-IMMUNE, HIGH-SPEED, LOW-POWER, GALLIUM ARSENIDE, DIGITAL INTEGRATED CIRCUITS
D.J. Fouts, Associate Professor

READ PREDICTION CACHE MEMORIES FOR EMBEDDED MICROPROCESSOR SYSTEMS
D.J. Fouts, Associate Professor

DYNAMIC LOGIC CIRCUITS FOR COMPLEMENTARY GALLIUM FABRICATION PROCESSES
D.J. Fouts, Associate Professor

EVALUATION OF CAD SOFTWARE FOR THE DESIGN OF VLSI ICs FOR DIGITAL SIGNAL PROCESSING APPLICATIONS
D.J. Fouts, Associate Professor

RADIATION TOLERANT BULK CMOS DIGITAL INTEGRATED CIRCUITS
D.J. Fouts, Associate Professor

RADIATION HARDENED SPACE BASED SOLAR CELLS AND ELECTRONIC DEVICES
S. Michael, Associate Professor

HIGH PERFORMANCE, RADIATION HARDENED IC TECHNOLOGY
T.R. Weatherford, Assistant Professor

LT GaAs IC DEVELOPMENT
T.R. Weatherford, Assistant Professor

Electrical and Computer Engineering Laboratories

The Electrical and Computer Engineering Department has excellent laboratory facilities in Microwaves and Antennas, Radar, Electronic Warfare, Optical Electronics, Transient Electromagnetics, Sonar Signal Processing, Control Systems, Power Systems, Image Processing, Very-Large-Scale Integration Design, and Digital Systems, as well as computer laboratories using high-speed microcomputers, UNIX-based workstations and distributed servers.

A wide array of computer facilities and software is available to support such areas as digital signal processing, control simulations, digital circuit simulation, digital system design, electromagnetics, power electronics and distribution, and image processing. There are also extensive service facilities including a calibration laboratory with a continuous program of calibration and maintenance for laboratory instruments. The department operates a secure computing and simulation laboratory, and has access to simulation and computing facilities in the Sensitive Compartmented Information Facility (SCIF) as well as a supercomputer and a scientific visualization facility in the School's computer center. A Worldwide SCI computer network is available in the SCIF.

Status as a Naval facility also enables the department to integrate modern defense systems into its laboratories. These include radar, telemetry, sonar, countermeasures, and navigation systems.

SIGNAL-TO-NOISE ENHANCEMENT PROGRAM (SNEP) RESEARCH AND SUPPORT

R.W. Adler, Senior Lecturer
W.R. Vincent, Research Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Security Group Command

OBJECTIVE: Continued research and development in techniques to improve the signal-to-noise ratio at Navy receiving sites worldwide.

SUMMARY: Development of techniques and methodology for identifying and locating radio noise sources at Naval Security Group (NSG) sites worldwide continued. Support was provided to NSG via review of pre-survey planning documentation, mitigation plans and authoring "Quick-Look" and final site-survey reports. Students and NSG site personnel were trained as part of the NSG support. A 2 1/2 day HF Technical Review of Factors that Affect Performance of Naval Receiving Sites was organized and was held in Washington, DC, in April.

PUBLICATIONS:

Perry, R.M., and Adler, R.W., "Evaluating Usefulness and Suitability of Groundwave Propagation Prediction Programs, Naval Postgraduate School Technical Report, NPS-EC-96-004, February 1996.

Vincent, W.R., "SNEP Team Quick-Look Report, NSGA, Kunia, HI, Regional Operational Site," SECRET, NSG Technical Report, February 1996.

Vincent, W.R., "SNEP Quick Look Report, NSGA, Hanza, Okinawa CDAA Site," NSG Technical Report, March 1996.

Vincent, W.R., and Munsch, G., "SNEP Power-Line Noise Mitigation Handbook," 3rd ed., COMMNAVSECGRU N-44, March 1996.

Vincent, W.R., "SNEP Team Quick-Look Report, NSGD, Sabana Seca, PR, CDAA Site," NSG Technical Report, April 1996.

Vincent, W.R., and Adler, R.W., "SNEP Team Quick-Look Report, NSGD, Rota, Spain, CDAA Site," NSG Technical Report, June 1996.

Vincent, W.R., and Adler, R.W., "SNEP Team Quick-Look Report, RSOC Kunia, HI," NSG Technical Report, July 1996.

Vincent, W.R., and Adler, R.W., "EMI Survey at RSOC, Kunia, HI," NSG Technical Report, July 1996.

Vincent, W.R., and Adler, R.W., "SNEP Team Quick-Look Report, NSGD Wahiahwa, HI," NSG Technical Report, July 1996.

Vincent, W.R., and Adler, R.W., "SNEP Team Quick-Look Report, NSGD Guantanamo Bay, Cuba," NSG Technical Report, September 1996.

Vincent, W.R., "SNEP Team Technical Report at the Sabana Seca, PR CDAA Site," NSG Technical Report, December 1996.

Vincent, W.R., "SNEP Team Technical Report, NSGA, Kunia, HI, Regional Operational Site," SECRET, NSG Technical Report, December 1996.

CONFERENCE PRESENTATIONS:

Adler, R.W., and Hoffman, "Using Amateur Radio CEM Codes to Gain Insight into VHF Ground Plane Antenna Performance and to Mitigate 75 Meter MARS RFI at a Naval Receiving Site," 12th Annual Review of Progress in Applied Computational Electromagnetics, Monterey, CA, March 1996.

Adler, R.W., "The Use of Simple Electromagnetic Modeling Software to Mitigate Encroachment at Naval Receiving Sites," Workshop on Factors Affecting the Performance of Naval Receiving Sites, Vienna, VA, April 1996.

Adler, R.W., "Mitigation of Digital Motor-Controller Radio Interference," Workshop on Factors Affecting the Performance of Naval Receiving Sites, Vienna, VA, April 1996.

Adler, R.W., "Radio Interference from Fluorescent Lights Using Energy-Efficient Electronic Ballasts," Workshop on Factors Affecting the Performance of Naval Receiving Sites, Vienna, VA, April 1996.

DoD KEY TECHNOLOGY AREAS: Sensors, Other (Environmental Effects)

KEYWORDS: Electromagnetic environmental effects, communication systems, man-made noise, antennas

ENHANCEMENTS FOR THE RADIO FREQUENCY MISSION PLANNER (RFMP)
R.W. Adler, Senior Lecturer
Department of Electrical and Computer Engineering
Sponsor: Naval Information Warfare Activity

OBJECTIVE: The goal of this ninth year of a continuing project was to conduct numerical analysis and experimental research in support of the Navy's requirement to site VLF through UHF communication antenna systems and support equipment in non-ideal locations. The effort this year was to support the propagation prediction models of the Radio Frequency Mission Planner (RFMP). In particular, the RFMP provides the warfighter an estimate of the probability of successfully receiving radio signals from 20 to 1500 MHz. The ionosphere does support 20 to 150 MHz in both the equatorial and the polar regions of the earth. The models used in RFMP require antenna performance factors. There were provided for a collection of base-station and vehicular antennas. The propagation models used in RFMP are tropospheric models only. Hence in the high- and low-latitude regions, RFMP will miss ionospheric paths and not predict some long-distance links. A rule-set to add to the tropospheric models was developed for those conditions under which Auroral E (Polar) and Transequatorial F layer paths can exist.

SUMMARY: An inexpensive equatorial propagation experiment has been completed to gather data for the rule set. The path mode was correlated with observed electron content. The data obtained was analyzed to provide a verification of propagation modes and existing prediction programs. A set of numerical models of various antennas of interest for RFMP was developed and delivered the ARL/Texas, NSG's agent for the development and maintenance of RFMP.

PUBLICATIONS:

Smith, R.W., and Adler, R.W., "Nighttime VHF Transequatorial Propagation," Naval Postgraduate School Technical Report, NPS-EC-009, June 1996.

Smith, R.W., Hunsucker, R.D., and Adler, R.W., "Nighttime VHF Propagation Across the Auroral Oval," Naval Postgraduate School Technical Report, NPS-EC-010, June 1996.

DoD KEY TECHNOLOGY AREAS: Sensors, Other (Environmental Effects)

KEYWORDS: Electromagnetic environmental effects, communication systems, man-made noise, antennas, radio-wave propagation

PROJECT SUMMARIES

SYSTEM MODELING AND ANALYSIS CENTER SUPPORT FOR
ANTENNA PERFORMANCE EVALUATION
R.W. Adler, Senior Lecturer
Department of Electrical and Computer Engineering
Sponsor: Naval Information Warfare Activity

OBJECTIVE: The System Modeling and Analysis Center (SMAC) is tasked to provide personnel and modeling tools to support all Tri-Service communication systems performance predictions for the warfighter. NPS is supporting this requirement by providing user-friendly numerical modeling tools. The first deliverable will be in 1997, a Windows graphical I/O interface for the NEC-MOM antenna code. Training will be provided on-site to the SMAC personnel in the form of a short course in conjunction with the Applied Research Lab of Penn State.

DoD KEY TECHNOLOGY AREAS: Sensors, Other (Environmental Effects)

KEYWORDS: Electromagnetic environmental effects, antennas

FIELD STATION RESEARCH AND SUPPORT
R.W. Adler, Senior Lecturer
Department of Electrical and Computer Engineering
Sponsor: U.S. Army Information Security Command

OBJECTIVE: Continued research and development in techniques to improve the signal-to-noise ratio at Army Regional SIGINT Operational Sites and receiving sites worldwide.

SUMMARY: An electromagnetic interference (EMI) survey was conducted at Ft. Gordon, GA. The performance of receiving signals-of-interest was evaluated and the EMI sources observed were documented.

PUBLICATION:

Vincent, W.R., and Adler, R.W., "EMI Survey at RSOC, Ft. Gordon, GA," USA INSCOM Technical Report, November 1996.

DoD KEY TECHNOLOGY AREAS: Sensors, Other (Environmental Effects)

KEYWORDS: Electromagnetic environmental effects, communication systems, man-made noise, antennas

B ANTENNA PERFORMANCE PREDICTIONS
R.W. Adler, Senior Lecturer
J.E. Lebaric, Visiting Associate Professor
Sponsor: Naval Surface Weapons Center-Crane Division

OBJECTIVE: The Naval Air System Command (NAVAIR) requires antenna performance parameters for EA6-B belly-mounted antennas for a proposal evaluation. NPS provides numerical electromagnetic models and performance for these proposed antennas.

SUMMARY: The antennas selected by NAVAIR match those modeled by NPS with best performance.

DoD KEY TECHNOLOGY AREAS: Sensors, Other (Environmental Effects)

KEYWORDS: Electromagnetic environmental effects, communication systems, antennas, radiowave propagation

CONVERTER DESIGN, ANALYSIS, AND PROTOTYPE FOR FUTURE NAVY SURFACE SHIPS
Robert William Ashton, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Surface Warfare Center-Carderock Division

OBJECTIVE: The object of this continuing project is to provide Naval Surface Warfare Center (NSWC) with six working 100kW DC-to-DC converters. The Naval Postgraduate School Power Systems Laboratory is responsible for the controllers and Power Paragon, Inc. (PPI) of Anaheim, CA, is responsible for the power portion on the prototypes.

SUMMARY: Through the use of previous thesis work by Mark Colby at NPS, a pseudo multiloop control scheme was chosen. This investigator designed, built and tested an analog multiloop controller which was used with a 10kW power section of a converter that was available during a six week venture at NSWC. After being satisfied with the overall results of the testing and a computer modeling effort, it was decided to make the controller more 'universal'. The multiloop control scheme was coded in SIMULINK by MATLAB converted to C and down loaded to a DSP controller from dSpace. After proof-of-concept by Gene Blalock, another thesis student at NPS, an autonomous DSP card was chosen during a second six week venture at NSWC. Coding was then written for the new DSP card, an SBC31 by Innovative Integration. Parallel simulation work utilizing the finished design of the power section by PPI was accomplished to determine converter stability and optimize control loop gains. Three in-house prototype 4kW DC-to-DC power sections were built and tested. The prototype IGBT power portions were used for hardware validation of computer simulations. A hard push was made during a January 1996 meeting at NPS between the Naval Surface Warfare Center, Power Paragon Incorporated (PPI) and Lockheed Martin to have two working units by July on 1996. This investigator was responsible for the prototype controllers and Power Paragon Incorporated of Anaheim was responsible for the power sections while Lockheed Martin over-looked the whole Navy project. Two analog/digital controller for the converters were completed at NPS in May with the help of a thesis student Benjamin Salerno. PPI had their power sections ready for integration with the NPS controllers in June. The integration was successfully completed in July at PPI with this investigator and a representative from NSWC. The units were then shipped to NSWC with the unfortunate event of damage to one of the controllers. After a trip to NSWC to help integrate the units in their facility and meet their new output and input voltage requirements by changing the control algorithm, it was discovered that the damaged controller board needed to be replaced after a catastrophic failure of one of the 100kW units. The project was finally completed in December after several more trips to correct the damaged unit. This project has now advanced to a new stage with new controller designs for more units in 1997.

THESES DIRECTED:

Salerno, B.D., "Controller Design, Analysis and Prototype for a Ship Service Converter Module," Master's Thesis, Naval Postgraduate School, June 1996.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Other (Power System Enhancement)

KEYWORDS: Power system, DC distribution, zonal architecture, stability

THE DEVELOPMENT AND HARDWARE IMPLEMENTATION OF A
PEBB-NETWORK SIMULATION TESTBED
Robert William Ashton, Assistant Professor
John G. Ciezki, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Surface Warfare Center-Carderock Division

OBJECTIVE: The investigators propose to design and construct a modular hardware testbed consisting of a set of DC-to-DC converters, Auxiliary Resonant Commutated Pole (ARCP) inverters, a Reconfigurable switching array and the requisite monitoring, protection and input/output connections. The testbed will facilitate the ready interconnection

of various topologies in order to study nonlinear interactions, paralleling schemes, load transients and fault conditions. All completed hardware components will be functionally tested and delivered to NSWC-CD/A as appropriate.

SUMMARY: The Navy is presently considering DC Zonal Electric Distribution (DC ZED) as an architecture for the twenty-first century combatant. The network topology will consist of a number of DC-to-DC converts modules and DC-to-AC inverter modules to provide the different types of power required for ship service and ship propulsion. The interaction and transient performance of such an interconnected nonlinear complex system is difficult to predict and there exists a need for a convenient means of assessing stability issues. The testbed will facilitate the ready interconnection of various topologies in order to study nonlinear interactions, paralleling schemes, load transients and fault conditions. Extensive progress has been made on the testbed which is to be delivered to NSWC 1 April 1997. The Source-Side DC-to-DC Converters are fully constructed and ready for mounting in the cabinet. Static full load tests have been successfully performed. Load-Side DC-to-DC Converter power sections are still under construction. DC-to-DC Converter Analog Controllers are tested and connected to the Source-Side Converters. The Load-Side Converters will be readied for optical interface for use with the PEBB Universal Controller. ARCP Inverters from Penn State University have been tested open-loop with the dSpace controller in the Power Systems Laboratory. The initial unit was sent back for several adjustments and EPROM reprogramming. The PEBB Universal Controller boards are ready for soldering. NPS has one working unit for software development. The original set of boards were incorrectly etched and a new set had to be ordered (vendor error). The cabinet which can be viewed in the Power Systems Laboratory has been populated with magnetic contractors for the switching array and awaits in-cabinet testing of the converters. The information for programming the PLDs for lock-out control has been acquired and the ABEL code is being synthesized.

THESIS DIRECTED:

Nelson, J.R., "Practical Implementation of a Quasi-Resonant DC Link Three-Phase Power Inverter in a Shipboard DC Power Distribution Network," Master's Thesis, Naval Postgraduate School, December 1996.

DoD KEY TECHNOLOGY AREAS: Other (Electronic Devices, Energy Conversion)

KEYWORDS: Power electronic building blocks, power system, DC distribution, zonal architecture, stability, simulator

ADVANCED DIGITAL LOGIC DESIGN
Jon T. Butler, Professor
Department of Electrical and Computer Engineering
Sponsor: Unfunded

OBJECTIVE: The design of modern digital logic circuits requires careful attention to the representation of the systems being designed. The purpose of this project is to develop techniques that allow the efficient design of such circuits.

SUMMARY: During the past year, the use of binary decision diagrams were investigated in designing efficient logic circuits. In one aspect of this project, planar or nearly planar circuits were analyzed. In such circuits, there are no or few places where interconnect cross. Crossings introduce delay and complexity in the circuit. For example, circuits that realize symmetric functions (an important class of functions) were characterized that do not have crossings. Circuits that have a specific decomposition, called a bi-decomposition were also investigated. Such functions are efficiently realized by certain recently developed field programmable gate arrays (FPGAs).

A paradigm for remote design of logic circuits was developed. The ultimate application of this work is the design of remote systems across the internet. This is an extension of the present JAVA paradigm in which programs are transmitted over the internet. The advantage of transmission of logic design is high speed; in effect, one is designing the hardware rather than specifying a program.

PROJECT SUMMARIES

PUBLICATIONS:

Butler, J.T., Nowlin, J.L., and Sasao, T., "Planarity in ROMDDs of Multiple-Valued Symmetric Functions," Proceedings of the 26th International Symposium on Multiple-Valued Logic, pp. 236-241, May 1996.

Butler, J.T., and Sasao, T., "Average Number of Nodes in Binary Decision Diagrams of Fibonacci Functions," The Fibonacci Quarterly, Vol. 34.5, pp. 413-422, November 1996.

Dueck, G.W., and Butler, J.T., "A Heat-Quench Algorithm for the Minimization of Multiple-Valued Programmable Logic Arrays," Computer and Electrical Engineering Journal, Vol. 22, No. 2, pp. 103-107, 1996.

Sasao, T., and Butler, J.T., "Planar Decision Diagrams for Multiple-Valued Functions," Multiple-Valued Logic: An International Journal (inaugural issue - invited paper), Vol. 1, pp. 39-64, 1996.

Sasao, T., and Butler, J.T., "On Bi-decompositions of Logic Functions," Information Processing Society of Japan Notes, Vol. 96, No. 121, pp. 9-16, 12 December 1996.

Sasao, T., and Butler, J.T., "Method to Represent Multiple-Output Switching Functions by Using Multi-Valued Decision Diagrams," Proceedings of the 26th International Symposium on Multiple-Valued Logic, pp. 248-254, May 1996.

CONFERENCE PRESENTATIONS:

Butler, J.T., Nowlin, J.L., and Sasao, T., "Planarity in ROMDDs of Multiple-Valued Video Symmetric Functions," 26th International Symposium on Multiple-Valued Logic, May 1996.

Sasao, T., and Butler, J.T., "Method to Represent Multiple-Output Switching Functions by Using Multi-Valued Decision Diagrams," 26th International Symposium on Multiple-Valued Logic, May 1996.

Sasao, T., and Butler, J.T., "On Bi-decompositions of Logic Functions," Information Processing Society of Japan Notes.

THESIS DIRECTED:

Nowlin, J.L., "Planarity in ROMDDs of Multiple-Valued Symmetric Functions," Master's Thesis, Naval Postgraduate School, March 1996.

DoD KEY TECHNOLOGY AREAS: Computing and Software

KEYWORDS: Logic design, remote design, binary decision diagram

LOW-POWER POWER ELECTRONIC BUILDING BLOCK GENERATION-ZERO HARDWARE ADAPTION AND DIGITAL CONTROL INTEGRATION
John G. Ciezki, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Surface Warfare Center-Carderock Division

OBJECTIVE: The goal of this research is to adapt existing hardware technology to implement a set of Power Electronic Building Block (PEBB) Generation-Zero components with high-bandwidth control capability. A PEBB is a power switch with integrated sensors and microcontroller capability. The PEBB-Zero components consist of several DC-to-DC converters and auxiliary resonant commutated pole (ARCP) inverters. The task includes modifying the power circuits to satisfy the power and frequency requirements, constructing the PEBB Universal Controller (Genera-

tion Zero), programming said controller using algorithms developed at NPS, and designing and building any interface circuitry.

SUMMARY: Personnel at the Naval Surface Warfare Center are interested in the design of Power Electronic Building Blocks for application in military equipment and on-board naval power systems. Such equipment has an integrated structure wherein the high-power circuitry coincides with the sensors and control apparatus. It is of interest to use existing technology to maximize the switching frequency and power density and construct "PEBB-Zero" hardware. NPS personnel utilized hardware provided by NSWC and Penn State University to synthesize a number of converters. Since flexibility was a key criterion for the converter controls, a Digital Signal Processor based controller was selected and the boards and parts were procured. The boards were populated and soldered at NPS and the interface boards designed and built. Due to an NSWC design flaw in the original IO board, implementation of the control algorithms had to be delayed until the next fiscal year. The resultant units will facilitate evaluation of existing technology bounds in terms of frequency and power and aid in the evaluation of future control algorithms.

DoD KEY TECHNOLOGY AREAS: Other (Electronic Devices, Energy Conversion)

KEY WORDS: DSP control, power electronic converters, simulation, control theory

THE DEVELOPMENT AND HARDWARE IMPLEMENTATION OF A POWER ELECTRONIC BUILDING BLOCK GENERATION-NETWORK SIMULATION TESTBED
John G. Ciezki, Assistant Professor
Department of Electronic and Computer Engineering
Sponsor: Naval Surface Warfare Center-Carderock Division

OBJECTIVE: The objective of this proposed work is to design and construct a modular hardware testbed to be used to investigate characteristics of DC Zonal Electric Distribution (DC ZED) and to study issues surrounding its implementation as the power system architecture for the 21st century combatant. The central elements of DC ZEDs are a high-voltage DC bus, various DC-to-DC and DC-to-AC converters with their associated controls, system monitoring devices and control elements, and network loads. The intent of the testbed design is to provide a reconfigurable switching array that permits ready interconnection of various component topologies in order to study nonlinear interactions, paralleling schemes, load transients, and fault conditions. It is also desired to have the testbed expandable to facilitate future efforts so that larger networks and new components can be integrated and considered.

SUMMARY: Personnel at the Naval Surface Warfare Center, Carderock Division, Annapolis, MD, are actively engaged in developing the DC Zonal Electric Distribution concept for application in the 21st century surface combatant. The interaction of components and the transient performance of such an interconnected nonlinear complex system is difficult to predict and, as such, a tool is necessary for acquiring data sets to be used in assessing performance, stability bounds, and proposed modifications. The cabinet was designed to use 49 magnetic contactors to realize a four-bus system and implement a number of auxiliary busses to facilitate rerouting power through simulated transmission lines. The unit is also equipped with a primary input outlet for 450V AC and two external input ports for injecting DC voltage, daisy-chaining power converters, or feeding back power from an inverter through a rectifier. The AC power is rectified with an on-board three-phase rectifier and 400V DC is made available to the source-side DC-to-DC converters. There are four DC-to-DC converters included in the testbed in addition to three Auxiliary Resonant Commutated Pole (ARCP) inverters that convert DC to three-phase AC. Two of the DC-to-DC converters are located at the 400V DC side and provide 300V DC to the four-bus network. The remaining two DC-to-DC converters are loads off of the main busses. The three ARCPs also act as loads off of the various busses. In addition to fabricating the various DC-to-DC converters and wiring the testbed cabinet, NPS personnel were responsible for the synthesis of the feedback controllers and all ancillary equipment needed to implement each of the power converters. Following the construction and validation of the testbed, the unit will be used for acquiring the various data sets required by NSWC to make educated judgements on system stability, performance, and modification.

DoD KEY TECHNOLOGY AREAS: Other (Electronic Devices)

KEYWORDS: Power electronic converters, power systems, DSP control

REAL TIME SENSOR BASED NAVIGATION AND CONTROL OF AUTONOMOUS UNDERWATER VEHICLES
Roberto Cristi, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Office of Naval Research

OBJECTIVE: This research addresses the development of a sonar based navigation system for underwater vehicles. Main problems are the modeling of the environment and the inclusion of vehicle motion and disturbances in the overall estimation scheme. The sonar head is a high frequency Tritech ST1000 pencil beam sonar operating at 1.25 MHz providing range information at any given bearing, used to map the environment surrounding the vehicle. A potential function is at the basis of the model for the environment, which provides for correction of the estimates in the vehicles position and velocity vectors. Several experiments have been conducted in a testing tank, which show the effectiveness of the technique.

PUBLICATIONS:

Cristi, R., Caccia, M., and Veruggio, G., "Motion Estimation and Modeling of the Environment for Underwater Vehicles," Proceedings of IARP 1996, Toulon, France, April 1996.

Cristi, R., Caccia, M., and Veruggio, G., "Sonar Environment Modeling and Motion Navigation in UUV Navigation," Proceedings of MMAR '96, Miedzyzdroje, Poland, September 1996.

Cristi, R., Caccia, M., and Veruggio, G., "Acoustic Estimation and Modeling of the Environment for Underwater Vehicles," submitted to the IEEE Transactions on Robotics and Automation, September 1996;

DoD KEY TECHNOLOGY AREAS: Surface/Under Surface Vehicles - Ships and Watercraft

KEYWORDS: Navigation, estimation, control

CONFERENCE INFORMATION SYSTEM
Monique P. Fargues, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Unfunded

OBJECTIVE: The main goal of this project is to investigate the design and implementation of a worldwide web information system for a technical conference held yearly.

SUMMARY: The project was divided into the following parts: the first one investigated the process correctly used by the conference organization, while the second part focused on the design and implementation of the computer-based information system developed to replace the current process in place. The resulting process streamlines the tasks involved in the conference's organization and reduces the workload of the administrative staff involved in the conference's preparations.

The first part of the study involved: the analysis of the conference structural organization, the analysis of the procedural flow of the conference, and the baseline assessment of the current process. The second part of the study involved: the selection of the hardware and the software to be used, the design of the computer-based information system, and the implementation of a portion of the system.

THESIS DIRECTED:

Chalfant, M.D., and Coats, K.M., "Design and Implementation of a Worldwide Web Conference Information System," Master's Thesis, Naval Postgraduate School, September 1996.

DoD KEY TECHNOLOGY AREAS: Computing and Software

KEYWORDS: Information system, worldwide web

<div align="center">

SIGNAL DENOISING USING WAVELET THRESHOLDING TECHNIQUES
Monique P. Fargues, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Undersea Warfare Center-New London Detachment

</div>

OBJECTIVE: The goal of the study is to investigate the application of the wavelet transform to denoising purposes. The proposed study is divided into two parts. The first part focuses on the type of decomposition and wavelet basis to be used, while the second part investigates specific wavelet thresholding techniques. The study focuses on data provided by the sponsor and results are compared to those obtained using classical Wiener filtering.

SUMMARY: This study investigated the application of the wavelet transform and wavelet and cosine packets signal decompositions for the removal of noise from underwater acoustic signals. Several wavelet-based denoising techniques were presented and their performances compared. Results from the comparisons were used to develop a wavelet-based denoising algorithm suitable for a wide variety of signals. Performances of the denoising algorithm were compared to those of a short-time Wiener filter implementation and demonstrated that wavelet-based methods are a viable tool for the denoising of acoustic data.

PUBLICATION:

Fargues, J.P., and Barsanti, R.J., "Wavelet-Based Denoising of Acoustic Transients," Proceedings of the 30th Asilomar Conference on Signals, Systems, and Computers, Pacific Grove, CA, November 1996.

CONFERENCE PRESENTATION:

Fargues, J.P., and Barsanti, R.J., "Wavelet-Based Denoising of Acoustic Transients," 30th Asilomar Conference on Signals, Systems, and Computers, Pacific Grove, CA, November 1996.

THESES DIRECTED:

Barsanti, R., "Denoising of Ocean Acoustic Signals Using Wavelet-Based Denoising," Master's Thesis, Naval Postgraduate School, December 1996.

Martin, J., "Speech Compression Using Cosine Packet Decomposition," Master's Thesis, Naval Postgraduate School, March 1996.

OTHER:

Fargues, J.P., "Underwater Signal Classification and Denoising Using Wavelet-Based Techniques," seminar given at NUWC-New London Detachment, August 1996.

Fargues, J.P., Barsanti, R., Martin, R., and Bennett, R., "Underwater Signal Classification and Denoising Using Wavelet-Based Techniques," Internal Report, August 1996.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Other (Electronic Devices)

KEYWORDS: Signal classification, wavelet transform

DETECTION AND CLASSIFICATION OF TRANSIENT SIGNALS USING WAVELETS
Monique P. Fargues, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Undersea Warfare Center-New London Detachment

OBJECTIVE: The goal of this on-going project is to investigate the application of the wavelet transform to classification of underwater signals.

SUMMARY: This study investigated the application of orthogonal and non-orthogonal wavelet-based procedures as feature extraction tools to classify several classes of underwater signals consisting of sperm whale, killer whale, pilot whale, humpback whale, gray whale, and underwater earthquake. A two-hidden-layers back-propagation neural network was used for the classification procedure. Results showed that the non-orthogonal undecimated A-trous implementation with multiple voices lead to the highest classification rate of 96.7%.

PUBLICATION:

Fargues, M.P., "Classification of Ocean Acoustic Data Using AR Modeling and Wavelet Transforms," Naval Postgraduate School Technical Report, NPS-EC-96-020, December 1996.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Other (Electronic devices)

KEYWORDS: Signal classification, wavelet transform

RADIATION-IMMUNE, HIGH-SPEED, LOW-POWER, GALLIUM ARSENIDE, DIGITAL INTEGRATED CIRCUITS
Douglas J. Fouts, Associate Professor
Todd R. Weatherford, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor: Space and Naval Warfare Systems Command, National Security Agency, and Naval Research Laboratory

OBJECTIVE: To develop a low-cost method for fabricating high-speed, low-power, gallium arsenide, field effect transistor, digital integrated circuits that are immune to radiation-induced, single-event upsets.

SUMMARY: Buried, low-temperature grown, gallium arsenide (GaAs) buffer layers are being investigated for use in GaAs wafers for digital integrated circuit (IC) fabrication processes. The effects of the buffer layer on transistor characteristics, circuit operation, and sensitivity to single event upsets (soft errors) are being characterized. Experimental results have reduced the soft error rate by up to six orders of magnitude. Simulations indicate that additional improvements are possible. The modified wafers being used are compatible with existing commercial wafer growth and IC fabrication processes. The results of this research will make it possible to turn any off-the-shelf or custom GaAs digital IC design into a radiation-hardened IC by fabricating the IC on a special wafer, avoiding the high costs associated with redesigning an IC for radiation tolerance and the required changes to the fabrication process.

PUBLICATIONS:

Fouts, D.J., Weatheford, T.R., Dale, C.J., Marshall, W., Dietrich, H.B., McMorrow, D., Abrokwah, J., LaMacchia, M., and Milano, R., "Soft-Error Immune Gallium Arsenide ICs Using COTS Designs and Foundries," Proceedings of the Government Microcircuit Applications Conference, Las Vegas, NV, 10-13 March 1997 (accepted).

Fouts, D.J., McMorrow, D., and Van Dyk, S.E., "Synchronized Single Event Error Testing of Ring Oscillators Using Pulsed Lasers," IEEE Transaction on Nuclear Science (submitted).

Weatherford, T.R., Marshall, P.W., Dale, C., McMorrow, D., Peczalski, A., Carts, M., and Twigg, M., "Soft Error Immune LT GaAs ICs," 1996 IEEE GaAs IC Symposium Technical Digest, November 1996.

CONFERENCE PRESENTATIONS:

Weatherford, T.R., Marshall, P.W., Dale, C., McMorrow, D., Peczalski, A., Carts, M., and Twigg, M, "Soft Error Immune LT GaAs ICs," 1996 IEEE GaAs IC Symposium, 6 November 1996.

Weatherford, T.R., Marshall, P.W., Dale, C., Peczalski, A., Baier, S., McMorrow, D., Dietrich, H., and Twigg, M., "Soft Error Results on Honeywell C-HIGFET ICs on LT GaAs Buffers," LT GaAs Workshop, Santa Barbara, CA, 7 March 1996.

Weatherford, T.R., Marshall, P.W., Dale, C., Peczalski, A., Baier, S., McMorrow, D., Dietrich, H., and Twigg, M., "Soft Error Results on Honeywell C-HIGFET ICs on LT GaAs Buffers," SEU Symposium, Los Angeles, CA, 17 April 1996.

THESES DIRECTED:

Amsler, D., "Design of a Universal Test Platform for Radiation Testing of Digital Components," Master's Thesis, Naval Postgraduate School, December 1996.

Mooney, C.S., "Design of a Satellite-Based Microelectronic Radiation Testing Experiment," Master's Thesis, Naval Postgraduate School, March 1996.

DoD KEY TECHNOLOGY AREAS: Electronics, Materials, Processes and Structures, Command, Control and Communications, Electronic Warfare, Computing and Software

KEYWORDS: Radiation-hardened electronics, space-qualified electronics, gallium arsenide integrated circuits, low-temperature grown gallium arsenide, high-speed logic.

READ PREDICTION CACHE MEMORIES FOR EMBEDDED MICROPROCESSOR SYSTEMS
Douglas J. Fouts, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Space and Naval Warfare Systems Command

OBJECTIVE: To develop an alternative to off-chip, second-level, cache memories for spacecraft, weapon systems, networking, and other embedded high-performance, low-power, microprocessor applications.

SUMMARY: Off-chip, second-level cache memories for high-performance microprocessor systems require large arrays of high-speed static RAM ICs, which greatly increases the power consumption, weight, physical size, and cooling requirements of the microprocessor system. By using address prediction techniques, a significantly smaller cache can provide the same performance with significantly reduced power consumption, weight, physical size, and cooling requirements. Single-chip VLSI implementations of read prediction caches are possible which can reduce

design time and improve system reliability. Inclusion of a read prediction cache memory on the actual CPU chip is also possible because of the reduced amount of logic required for implementation.

PUBLICATION:

Fouts, D.J., Nowicki, G.J., Aguilar, M.E., "A CMOS Read Prediction Buffer IC for Embedded Microprocessor Systems," IEEE Transactions on VLSI Systems (submitted).

THESES DIRECTED:

Robert, J.R., Jr., "The Design of a Predictive Read Cache," Master's Thesis, Naval Postgraduate School, March 1996.

Altmisort, F.N., "Development of a New Prediction Algorithm and Simulator for the Predictive Read Cache," Master's Thesis, Naval Postgraduate School, September 1996.

Camliguney, A., "Simulation and Analysis of Predictive Read Cache (PRC) Performance," Master's Thesis, Naval Postgraduate School, September 1996.

OTHER:

A high-performance, general-purpose, computer architecture simulation program has been written for performing address-trace driven simulations of instruction execution, address patterns, and cache memory and main memory behavior.

DoD KEY TECHNOLOGY AREAS: Electronics, Computing and Software, Command, Control and Communications, Electronic Warfare

KEYWORDS: Embedded computing, portable computing, high-speed networking, high-performance microprocessors

DYNAMIC LOGIC CIRCUITS FOR COMPLEMENTARY GALLIUM FABRICATION PROCESSES
Douglas J. Fouts, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: National Security Agency

OBJECTIVE: To investigate the speed, power consumption, and noise sensitivity of dynamic logic circuits implemented with complementary gallium arsenide fabrication processes.

SUMMARY: Logic circuits implemented with gallium arsenide (GaAs) metal field effect transistors (MESFETs) can consume fairly large amounts of power when operated at high frequencies. An alternative is to implement the logic with complementary hetero isolated gate field effect transistors (CHIGFETs). This yields logic circuits with reduced power consumption but also reduced speed. However, by using the new dynamic logic circuits that have been developed by this research project, in conjunction with a CHIGFET fabrication process, the high speed of GaAs MESFET logic can be maintained while at the same time reducing the power consumption to a level that is below the power consumption for the static logic circuits that are more typically used with CHIGFET fabrications processes.

PUBLICATIONS:

Shehata, K.A., and Fouts, D.J., "Two-Phase Dynamic Logic Circuits for Complementary GaAs Processes," Proceedings of the 1997 Symposium on VLSI Technology, in Japan (submitted).

Shehata, K.A., and Fouts, D.J., "Low-Power High-Speed Complementary GaAs Dynamic Logic Circuit Design," Proceedings of the 1997 Symposium on VLSI Technology, in Taiwan (submitted).

CONFERENCE PRESENTATIONS:

Shehata, K.A., and Fouts, D.J., "Complementary Gallium Arsenide Low-Power High-Speed Dynamic Logic," Workshop on Complementary Heterostructure FET (CHFET) Technology, Albuquerque, NM, 18-19 November 1996.

DISSERTATION DIRECTED:

Shehata, K.A., "Low-Power High-Speed Dynamic Logic Families for Complementary Gallium Arsenide (CGaAs)," Ph.D. Dissertation, Naval Postgraduate School, September 1996.

DoD KEY TECHNOLOGY AREAS: Electronics, Computing and Software, Command, Control and Communications, Electronic Warfare

KEYWORDS: Dynamic logic, gallium arsenide logic, dynamic gallium arsenide logic, high-speed low-power logic

EVALUATION OF CAD SOFTWARE FOR THE DESIGN OF VLSI INTEGRATED CIRCUITS FOR DIGITAL SIGNAL PROCESSING APPLICATIONS
Douglas J. Fouts, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: National Security Agency

OBJECTIVE: To evaluate computer-aided design software tools for their potential use in designing radiation-hardened VLSI digital ICs.

SUMMARY: This research project investigated the use of advanced Computer Aided Design (CAD) tools for designing radiation-hardened digital integrated circuits. Chips designed with these tools would be radiation hard because of their design and could thus be fabricated at standard, commercial IC fabrication facilities. This would greatly reduce the cost and increase the availability of radiation-tolerant components for space applications.

PUBLICATION:

Gallander, T.J., and Fouts, D.J., "Design Tradeoffs in Radiation Hardened ASICs for Space Applications," Proceedings of the Government Microcircuit Applications Conference, Las Vegas, NV, 10-13 March 1997 (accepted).

THESIS DIRECTED:

Gallander, T.J., "Design Tradeoffs in Radiation Hardened ASICs for Space Applications," Master's Thesis, Naval Postgraduate School, June 1996.

OTHER:

This research has produced two versions of a custom VLSI digital integrated circuit. The IC is a 32-tap, finite input response filter for digital signal processing. Version one of this chip was fabricated with a standard, commercial CMOS process. Version two of this chip was fabricated with the same process, but the design was radiation hardened using the CAD tools being evaluated.

DoD KEY TECHNOLOGY AREAS: Electronics, Computing and Software, Command, Control and Communications, Electronic Warfare

RADIATION TOLERANT BULK CMOS DIGITAL INTEGRATED CIRCUITS
Douglas J. Fouts, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: National Security Agency

OBJECTIVE: To develop circuit designs and mask layout techniques that improve the radiation tolerance of digital integrated circuits fabricated with bulk CMOS processes.

SUMMARY: This FY97 research project is the follow-on project to the FY96 research project titled "Evaluation of CAD Software for the Design of VLSI ICs for Digital Signal Processing Applications." This research is investigating the feasibility of fabricating radiation-tolerant CMOS ICs with standard commercial CMOS fabrication processes. Circuit designs and mask layout techniques are being investigated to determine if they will yield enough radiation tolerance such that commercial IC fabrication processes can be used, thus eliminating the high costs of maintaining a separate fabrication line for radiation-hardened components.

DoD KEY TECHNOLOGY AREAS: Electronics, Computing and Software, Command, Control and Communications, Electronic Warfare

KEYWORDS: Radiation-hardened electronics, space electronics

EXPLOITATION OF POTENTIAL JAMMING CAPABILITY OF ULTRA WIDEBAND SOURCE (UWBS)
Tri T. Ha, Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Postgraduate School

OBJECTIVE: The purpose of this research is to exploit the potential jamming capability of ultra wideband source (UWBS) against spread spectrum communication systems and to study countermeasures. Investigations include mobile environment, exploitation of the deterministic characteristics of UWBS signals, modulation waveforms that are jam-resistant and forward error correction.

SUMMARY: Simulation results of the error probabilities for the DSSS/BPSK and the FHS/BFSK systems in an UWBS interference were presented. The AWGN channel and the Rayleigh channel were considered with and without convolutional code. It was shown that given the same jammer power, an UWBS interference is more effective on the FHSS/BFSK system than the DSSS/BPSK system in causing a higher bit error probability. In particular, it was shown that given the same jammer power, the jammer is more effective by operating at a higher PRF or with a narrower pulse width. In addition, the coding gains achieved with the convolutional code to reduce the UWBS jamming effect in both the AWGN channel and the Rayleigh fading channel were presented. The results have shown that the coding gain in the Rayleigh fading channel is at least an order higher than achieved in the AWGN channel.

THESIS DIRECTED:

Yeu, E.-K., "Error Probabilities of Spread Spectrum Systems in Ultra Wideband Source (UWBS) Interference," Master's Thesis, Naval Postgraduate School, September 1996.

Christofis, E., "Performance Analysis of FFH/BPSK with Convolutional Coding and Soft Decision Viterbi Decoding over Channels with Partial-Band Noise Interference," Master's Thesis, Naval Postgraduate School, March 1996.

DoD KEY TECHNOLOGY AREAS: Command, Control and Communications

PROCESSING OF SECOND ORDER STATISTICS VIA WAVELET TRANSFORMS
Ralph Hippenstiel, Associate Professor
Monique P. Fargues, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Secretary of the Air Force

OBJECTIVE: The goal of this project is to investigate the properties of a wavelet based approach in detecting and classifying digital modulated signals. Frequency hopped (FH) signals are of special interest.

SUMMARY: Research was conducted to evaluate the feasibility of applying wavelet transforms to second order statistics. In particular, the instantaneous correlation function was used in analytical and experimental work. Preliminary results indicate that a wavelet based processing scheme coupled with traditional processing can be computationally efficient and allow the extraction of desired signal parameters from FH type signals.

PUBLICATION:

Khalil, N., and Hippenstiel, R., "Wavelet Transforms of Correlation Functions of Frequency Hopped Signals," Proceedings of the 30th Asilomar Conference on Signals, Circuits and Computers, Pacific Grove, CA, November 1996.

CONFERENCE PRESENTATION:

Khalil, N., and Hippenstiel, R., "Wavelet Transforms of Correlation Functions of Frequency Hopped Signals," the 30th Asilomar Conference on Signals, Circuits and Computers, Pacific Grove, CA, November 1996.

DoD KEY TECHNOLOGY AREAS: Other (Electronic Devices)

KEYWORDS: Communication intercept, wavelets, detection, demodulation, parameter identification

WAVELET BASED TRANSMITTER IDENTIFICATION
Ralph Hippenstiel, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Unfunded

OBJECTIVE: The goal of this project was to investigate wavelet based processing techniques as they allow automated transmitter identification.

SUMMARY: Research was conducted to evaluate the feasibility of using a wavelet based approach to identify the transmitter of electronic communication system. The dominant terms allowing identification were found in the characteristic turn on signature of a given transmitter. The study included an assessment as to how sensitive the wavelet based approach is to noise. Spectral correlation was also successfully used to obtain signal classification. Future work should be focused on an automatic threshold selection, a robust template selection, improved ways to associate the scale outputs and robust ways to use several scale outputs simultaneously.

PUBLICATION:

Hippenstiel, R., and Payal, Y., "Wavelet Based Transmitter Identification," Proceedings of the 4th International Symposium on Signal Processing and its Applications, ISSPA'96, Gold Coast, Australia, August 25-30 1996.

PROJECT SUMMARIES

THESIS DIRECTED:

Abdulla, A., "Identification of Push-to-Talk Transmitters Using Wavelets and Spectral Correlation," Master's Thesis, Naval Postgraduate School, September 1996.

DoD KEY TECHNOLOGY AREAS: Other (Electronic Devices)

KEYWORDS: Communication intercept, wavelets, detection, demodulation, parameter identification

MISSILE CLOSURE SIMULATION AND ANALYSIS TO SUPPORT TESTING MISSILE APPROACH WARNING SYSTEMS
Robert G. Hutchins, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Air Warfare Center-Weapons Division

OBJECTIVE: The Naval Air Warfare Center-Weapons Division (NAWC-WD) is undertaking a study of simulation methodologies to support testing of missile approach warning systems (MAWS). They have two programs of interest in this area, the Missile on the Mountain-Ground Mounted Seeker (MOM-GMS) radar enhancement project at the Electronic Combat Range, China Lake, CA, and the Joint Electronic Combat test using SIMulation (JECSIM) Joint Test and Evaluation (JT&E) program. The Naval Postgraduate School (NPS) has been tasked to assist in this effort along two paths: first by acting as the focal point for missile fly-out simulations and studies, and second to assist in the RF portion of the MAWS study by developing and implementing real-time algorithms to assist a ground-mounted, stationary RF seeker to perceive a more realistic view of incoming targets through the use of simulation enhancements. Missile fly-out simulations remain the dominant concern for the timeframe covered in the FY96 work. This study will address: a characterization of missile fly-out trajectories and end-game behavior for selected threat missiles, based on government-furnished enhance surface-to-air missile simulation (ESAMS) missile fly-out simulation code, a comparison of these trajectories with the results obtained with in-house NPS simulations the previous year, and a more thorough investigation of end-game trajectories and other phenomena of importance for RF seeker simulation during end-game.

SUMMARY: NAWCWD is involved in a large tri-service effort to develop testing procedures for assessing aircraft response mechanisms to threat surface-to-air missile (SAM) systems. To this end, realistic sensors, sensor simulators, missile fly-out geometries and end-game intercept geometries for a wide band of sensor types and missile types must be assessed. Earlier research on this project at NPS included obtaining the enhance surface-to-air missile simulation (ESAMS) code from the Survivability/Vulnerability Information Analysis Center (SURVIAC) at Wright Patterson AFB and performing test and evaluation on this code using an SGI Indigo2 computer in the classified computer facility in Root Hall (this code is classified SECRET). This past year's research centered around simulation studies using ESAMS to validate missile end-game behavior for specific threat systems. Specific end-game studies were undertaken and a classified briefing was given at NAWCWD, China Lake on 30 September, where results were presented. Also, updated ESAMS code was delivered to NPS and hosted in the classified computer facility. Funding has been continued in this effort for next year, where the focus will be on validating simulation algorithms using actual missile fly-out data obtained from test flights done at China Lake. Actual flight test data has been obtained from some early missile firings, but analysis has not yet begun. This year's analysis will focus on the SA-6.

DoD KEY TECHNOLOGY AREAS: Sensors, Electronic Warfare, Modeling and Simulation

KEYWORDS: Sensors, integration, missile guidance, real-time simulation

EVALUATION AND EXTENSIONS OF THE PROBABILISTIC MULTI-HYPOTHESIS TRACKING ALGORITHM TO CLUTTERED ENVIRONMENTS

Robert G. Hutchins, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Undersea Warfare Center-Newport Detachment

OBJECTIVE: Dr. Roy Streit and colleagues at the Naval Undersea Warfare Center-Newport Detachment, have developed a probabilistic multi-hypothesis tracking (PMHT) algorithm that simplifies multi-hypothesis tracking and thus extends the applicability of these techniques to a broader range of problems. Analysis and testing to date have not included three key areas: a comparison with a traditional MHT algorithm, the study of cluttered environments, nor the use of attribute data in measurement-to-track association. The purpose of the research effort at NPS is four-fold: to test and validate this new algorithm by comparing it with a traditional MHT algorithm using standardized test scenarios, to study comparative algorithm performance in the presence of clutter, to enhance system performance by revising clutter initiation procedures, and to initiate a study of attribute-augmented measurement-to-track association procedures for potential inclusion in the new algorithm at a later date. The ultimate goal is to develop a workable set of algorithms that is practical and that will achieve reasonable performance in the presence of clutter.

SUMMARY: This year the project completed construction of all simulation testbeds, completed coding of all algorithms, and ran comparison studies of competing tracking algorithms in varying conditions. Specifically addressed was tracking in clutter with varying clutter densities, track initialization problems and procedures, measurement preprocessing, and the use of attribute data for clutter reduction.

PUBLICATIONS:

Hutchins, R.G., and Dunham, D.T., "Evaluation of a Probabilistic Multi-Hypothesis Tracking Algorithm in Cluttered Environments," Proceedings of the 30th Asilomar Conference on Signals, Systems, and Computers, Pacific Grove, CA, November 1996.

Hutchins, R.G., "Neural Network Chaotic System Identification," Proceedings of the 30th Asilomar Conference on Signals, Systems, and Computers, Pacific Grove, CA, November 1966.

Hutchins, S.G., and Hutchins, R.G., "Decision Support for Enhancing Tactical Air Situation Awareness," Proceedings of the 1st Annual Symposium on Situation Awareness in the Tactical Air Environment, Patuxent River NAS, MD, 4-5 June 1996.

CONFERENCE PRESENTATIONS:

Hutchins, R.G., and Dunham, D.T., "Evaluation of a Probabilistic Multi-Hypothesis Tracking Algorithm in Cluttered Environments," 30th Asilomar Conference on Signals, Systems, and Computers, Pacific Grove, CA, November 1996.

Hutchins, R.G., "Neural Network Chaotic System Identification," 30th Asilomar Conference on Signals, Systems, and Computers, Pacific Grove, CA, November 1966.

Hutchins, S.G., and Hutchins, R.G., "Decision Support for Enhancing Tactical Air Situation Awareness," 1st Annual Symposium on Situation Awareness in the Tactical Air Environment, Patuxent River NAS, MD, 4-5 June 1996.

Hutchins, R.G., "Modeling and Simulation in Electronic Warfare," 3rd Modeling and Simulation Conference, sponsored by the Association of Old Crows, Mitre Corporation, McLean, VA, 7 March 1996.

THESES DIRECTED:

Klein, G.D., "Linear Modeling of Tilrotor Aircraft (in Helicopter and Airplane Modes) for Stability Analysis and Preliminary Design, Master's Thesis, Naval Postgraduate School, June 1996.

Poor, C.A., "Simulink Modeling of Marine Autopilots for TSSE Ship Designs," Master's Thesis, Naval Postgraduate School, December 1996.

DoD KEY TECHNOLOGY AREAS: Sensors, Modeling and Simulation

KEYWORDS: Sensors, data association, target tracking

MODELING RADIOWAVE PROPAGATION OVER TERRAIN AND ROUGH OCEAN SURFACE
Ramakrishna Janaswamy, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Command Control and Ocean Surveillance Center

OBJECTIVE: To develop numerical techniques for modeling radiowave propagation in littoral regions including the effects of terrain features and sea states.

SUMMARY: In the first part of the project, we have developed a new methodology for incorporating ocean surface roughness into the split-step parabolic equation formulation. The rough ocean surface is replaced with a plane wave reflecting surface whose reflection coefficient is characterized in the spectral domain. This has the advantage of accommodating contributions from all waves contained in the spectral (angular) decomposition of the field. Results have been generated for horizontal polarization and compared favorably with the waveguide model.

In the second part of the project, we have developed a curvilinear coordinate based split-step parabolic equation approach for propagation predictions over terrain. A curvilinear coordinate system is generated by the specification of terrain elevations at discrete points along the path between a transmitter and a receiver. The intervening path is allowed to have refractive index variations. Ground electrical data is taken into account by means of the impedance boundary condition for the electromagnetic fields. In the numerical marching scheme, no interpolation/extrapolation of data is needed in going in the upslope or downslope directions in the split-step technique. Results have been generated both for vertical and horizontal polarizations and compared with experimental data as well as with results from other methods. Very good agreement was seen.

PUBLICATIONS:

Janaswamy, R., "An Extension of the Split-Step Parabolic Equation Technique to Include Ocean Surface Roughness," submitted to IEEE Transactions on Antennas and Propagation, October 1996.

Janaswamy, R., "Propagation Predictions Over Terrain Using Curvilinear Coordinate Based Parabolic Equation,'" submitted to IEEE Transactions on Antennas and Propagation, August 1996.

Janaswamy, R., and Liu, Y., "An Unstaggered, Colocated Finite Difference Method for Solving Time Domain Maxwell's Equations in Curvilinear Coordinates," submitted to IEEE Transactions on Antennas and Propagation, February 1996.

CONFERENCE PRESENTATIONS:

Janaswamy, R., Hitney, H.V., Barrios, A., and Anderson, K.D., "A Rough Surface Split-Step Parabolic Equation Method for Radiowave Propagation," presented at the National Radio Science Meeting, Boulder, CO, 9-13 January 1996.

Vlachos, K., and Janaswamy, R., A Wide Angle Split-Step Parabolic Equation Scheme for Tropospheric Propagation Over Irregular Terrain," 1996 PIERS Symposium, Innsbruck, Austria.

THESIS DIRECTED:

Vlachos, K., "A Wide Angle Split-Step Parabolic Equation Model for Propagation Predictions Over Terrain," Master's Thesis, Naval Postgraduate School, March 1996.

DoD KEY TECHNOLOGY AREAS: Other (Environmental Effects)

KEYWORDS: Radiowave propagation, parabolic equation, rough surface

NEAR-FIELD NEED-TO-CALIBRATE INDICATOR FOR SHIPBOARD HF ANTENNAS
David C. Jenn, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Space and Naval Warfare Systems Command

OBJECTIVE: The objective of this research is to investigate possible methods of calibration of shipboard DF systems, or at least developing a means of determining whether a need to calibrate exists.

SUMMARY: High frequency direction finding (HFDF) systems are subject to a lengthy and expensive calibration process once they are installed onboard a ship. The primary purpose of the calibration is to generate a data base of antenna responses for a predetermined set of frequencies and angles. In the past, when a topside change was made to a ship, the DF system was generally recalibrated even though there has been no well-defined measurable criteria for the need to recalibrate. This research has developed a "need to calibrate indicator" based on a numerical electromagnetics code computer simulation of DF systems on a DD963 class ship. A test procedure has been written and the measurement demonstrated on the *USS Kinkaid* in August 1996.

CONFERENCE PAPER:

Knorr, J.B., and Jenn, D.C., "A Numerical and Experimental Investigation of a Semi-Loop Antenna on a Metal Box," Proceedings of the 12th Annual Review of Progress in Applied Computational Electromagnetics, Monterey, CA, pp. 832-839, 18-22 March 1996.

CONFERENCE PRESENTATION:

Jenn, D., "Test Plan for a Shipboard Demonstration of the Need-to-Calibrate Indicator," SPAWAR PMW-163 Baseline Review, Washington, DC, 28 February 1996.

TECHNICAL REPORTS:

Jenn, D., "Automatic Meshing of CAD Ship Files for Use With Numerical Electromagnetics Codes," Naval Postgraduate School Technical Report, NPS-EC-96-012, July 1996.

Jenn, D., "Shipboard Demonstration of the Near-Field Need-to-Calibrate Indicator," Naval Postgraduate School Technical Report, NPS-EC-96-017, September 1996.

Jenn, D., "Computer Simulation of a Near-Field Need-to-Calibrate Indicator for Shipboard HFDF Systems," Naval Postgraduate School Technical Report, NPS-EC-96-019, September 1996.

DoD KEY TECHNOLOGY AREAS: Electronic Warfare, Sensors, Modeling and Simulation

KEYWORDS: Direction finding, numerical electromagnetics

SURVEILLANCE SYSTEM STUDIES (PRIVATE)
Jeffrey B. Knorr, Professor
Department of Electrical and Computer Engineering
Sponsors: Space and Naval Warfare Systems Command and
Naval Postgraduate School

OBJECTIVE: The objective of this project was to investigate the feasibility of using a computer simulation of a high frequency, shipboard direction finding system as a recalibration decision support system. This project was initiated in 1994 and completed in 1996.

SUMMARY: Shipboard direction finding (DF) in the high frequency (HF) band is complicated by the fact that the antenna elements in the DF array interact strongly with the ship's superstructure. Thus, a DF technique such as correlation interferometry direction finding (CIDF), which accounts for the effects of the superstructure must be used. However, CIDF requires a calibration database of DF antenna responses and any changes made to the superstructure after calibration may affect the accuracy of bearing estimates. This poses a problem, as one must know when a topside change will result in the need to recalibrate a ship; a costly and time consuming process.

A computer simulation was developed using operational system software. It was constructed to accept numerical, scale model, or real ship data and to display correlation and bearing error results using 2D and 3D graphic displays. Numerical models of the DD963 Spruance Class destroyer were developed for two different topside configurations. The models were numerically calibrated and the bearing error caused by changing configuration was determined. Experimental data were used to validate the simulation.

Results were obtained at four frequencies through the HF band. Numerical and experimental DF antenna responses were in good agreement at the lower frequencies. At the higher frequencies, numerical and experimental DF antenna responses were not in good agreement. This was attributed to correctable deficiencies in the numerical ship models. Similarly, numerical and experimental correlation and bearing error results showed good agreement at low frequencies and poor agreement at high frequencies. However, numerical and experimental values of RMS bearing error, which is an integrated performance measure, showed good correspondence at all frequencies.

This work has shown that computer simulation could be used as a basis for developing a ship recalibration decision support system. Areas requiring further development to facilitate this approach include: (1) generation of ship numerical models from CAD files, (2) development of EM code pre/post processors for editing input data files, (3) visualization of input data files, and (4) viewing output data files. A comparison of the performance of available EM codes for this application would also be desirable. The simulation is immediately useful for analysis of real ship data.

PUBLICATIONS:

Knorr, J.B., and Jenn, D.C., "A Numerical and Experimental Investigation of a Semi-Loop Antenna on a Metal Box," Proceedings of the 12th Annual Review of Progress in Applied Computational Electromagnetics, Monterey, CA, pp. 832-839, 18-22 March 1996.

Knorr, J.B., "A Numerical and Experimental Investigation of a Shipboard DF Antenna Array," Proceedings of the 12th Annual Review of Progress in Applied Computational Electromagnetics, Monterey, CA, pp. 792-801, 18-22 March 1996.

Neta, B., and Knorr, J.B., "Running NEC4 on the Cray at NPS," Applied Computational Electromagnetics Society Newsletter, Vol. 11, No. 3, pp. 12-15 November 1996.

CONFERENCE PRESENTATIONS:

Knorr, J.B., and Jenn, D.C., "A Numerical and Experimental Investigation of a Semi-Loop Antenna on a Metal Box," 12th Annual Review of Progress in Applied Computational Electromagnetics, Monterey, CA, 18-22 March 1996.

Knorr, J.B., "A Numerical and Experimental Investigation of a Shipboard DF Antenna Array," 12th Annual Review of Progress in Applied Computational Electromagnetics, Monterey, CA, 18-22 March 1996.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Command, Control and Communications, Electronic Warfare, Modeling and Simulation, Sensors

KEYWORDS: Direction finding, DF, HFDF, modeling and simulation, computational electromagnetics, CEM

DEVELOPMENT OF SIMULINK MODEL FOR UNMANNED AERIAL VEHICLE (UAV) ELECTRIC PROPULSION SIMULATION
Jovan Lebaric, Visiting Associate Professor
Richard Adler, Senior Lecturer
Department of Electrical and Computer Engineering
Sponsor: Naval Research Laboratory

OBJECTIVE: The objective of this project was to develop a computer model of the Electric Propulsion system for an Unmanned Aerial Vehicle (EP-UAV) consisting of a high-efficiency Permanent Magnet Brushless DC motor and motor controller and a high energy density battery pack.

SUMMARY: A UAV electric propulsion computer model was developed using SIMULINK software environment that allows users to "fly" the UAV using different flight regimes and determine the corresponding UAV ranges and efficiencies. By varying the EP-UAV parameters such as payload weight, battery weight, propeller size and type, etc., the effects of these on the EP-UAV range and efficiency can be established prior to the actual design and prototyping. Specifically, the SIMULINK model can be used to: 1) determine the minimum time that a certain mission would take for given battery/motor resources, 2) determine the flight regime that maximizes the UAV range or the time it can stay over an area, and 3) determine the flight regime such that a mission is accomplished with the least expenditure of energy (maximum battery "reserve").

THESIS DIRECTED:

Yourkowski, D., "Computer Simulation of an Unmanned Aerial Vehicle Propulsion System," Master's Thesis, Naval Postgraduate School, March 1996.

DoD KEY TECHNOLOGY AREAS: Air Vehicles, Modeling and Simulation

KEYWORDS: Propulsion, modeling, aircraft

RF FREQUENCY AND POWER MANAGEMENT
Chin-Hwa Lee, Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Command, Control and Ocean Surveillance Center and Naval Postgraduate School

OBJECTIVE: To develop automatic frequency reuse and power control techniques to allow reuse of assigned line of sight frequencies within a mobile ship to ship/air/shore RF-mesh network.

SUMMARY: In the era of emphasizing joint operations and littoral water warfare, frequency congestion and channel interference are the most important challenges. Investigation is concentrated on distributed schemes for automatic link establishment and power control. Power control is located in OSI layer 2, and it is similar to open loop power control (in CDMA) to compensate path loss. The objective is to find the appropriate protocols to handle this situation in simulation.

PUBLICATION:

Lee, C.H., and North, R., "Decentralized Power Management in RF Mesh Networks for Frequency Reuse," Proceedings of the 30th Asilomar Conference on Signals, Systems, and Computers, Monterey, CA, November 1996.

CONFERENCE PRESENTATIONS:

Lee, C.H., "Decentralized Power Management in RF Mesh Networks for Frequency Reuse," 30th Asilomar Conference on Signals, Systems, and Computers, Pacific Grove, CA, November 1996.

Lee, C.H., "Decentralized Power Management in RF Mesh Networks for Frequency Reuse," Workshop on New Techniques for Radio Communications and Wireless Networks, NRaD, San Diego, CA, September 10 1996.

THESIS DIRECTED:

Hsu, H.-M., "Radiated Power Control for Narrow-band Digital Links," Master's Thesis, Naval Postgraduate School, March 1996.

DoD KEY TECHNOLOGY AREAS: Command, Control and Communications

KEYWORDS: Digital communication, mobile wireless network, line of sight communication

ADVANCED PHASED ARRAY ANTENNA TECHNOLOGIES
Chin-Hwa Lee, Professor
Department of Electrical and Computer Engineering
Sponsor: Office of Naval Intelligence

OBJECTIVE: Access performance and costs of advanced phased array antenna technologies in emerging radar systems.

SUMMARY: The study involves investigation of nine Active phased array radar systems in development around the world. Examine the performance versus costs that indicates the future trend of the new radar systems.

PUBLICATION:

Lee, C.H., "RF Link Power Control with Field Test Data," Proceedings of the 30th Asilomar Conference on Signals, Systems, and Computers, Pacific Grove, CA, November 1996.

CONFERENCE PRESENTATION:

Lee, C.H., "RF Link Power Control with Field Test Data", 30th Asilomar Conference on Signals, Systems, and Computers, Pacific Grove, CA, November 1996.

THESIS DIRECTED:

Micheli, V.A., "Active Phased Array Radar Analysis," Master's Thesis, Naval Postgraduate School, September 1996.

DoD KEY TECHNOLOGY AREAS: Sensors

KEYWORDS: Radar, antenna

ELECTRO-MAGNETIC SCATTERING FROM A TUBULAR CYLINDER
OF ANISOTROPIC SURFACE IMPEDANCES
H.-M. Lee, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Unfunded

OBJECTIVE: To investigate the effects of impedance coating on the scattering of electromagnetic waves by a body in the resonant region.

SUMMARY: The electromagnetic scattering from a zero-thickness, perfectly conducting, circular, tubular cylinder of finite length with different anisotropic coatings on its inside and outside surfaces is investigated. The induced electric and magnetic surface current densities and the far field are obtained. Analytical expressions of the double series expansion coefficients of the kernels of the integral-differential equations of this problem are found and utilized in the computation to assure that extremely accurate numerical results can be obtained. These results will be used as a standard for validating numerical electromagnetic computation codes.

PUBLICATION:

Yu, C.-K., and Lee, H.-M., "Zero On-Axis Backscattering of an Anisotropically Coated Shell of Revolution," Naval Postgraduate School Technical Report, NPS-EC-96-005, May 1996.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Electronics, Electronic Warfare

KEYWORDS: Radar cross section, sensors, low observables

LOW ALTITUDE INFRARED PROPAGATION ABOVE OCEAN
H.-M. Lee, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Unfunded

OBJECTIVE: To examine the fluctuation in the strength of low altitude propagation of infrared beam above ocean surface to determine the effects of temperature profile and ocean waves.

SUMMARY: Fluctuation in the received strength of infrared beam transmitted over the ocean surface is investigated. The temperature, wind speed and ocean wave data are used to construct the temperature profile to correlate with the recorded IR beam strength information. The results should improve our understanding of the effects of ocean environment on IR sensors.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Sensors

KEYWORDS: IR sensor, environmental effects

PROJECT GUSTY ORIOLE
Herschel H. Loomis, Jr., Professor
Department of Electrical and Computer Engineering
Thomas C. Betterton, RADM, USN (Ret)
Naval Space Technology Chair Professor of Space Systems
Space Systems Academic Group
Michael Melich, Professor
Department of Physics
Frank Kragh, Research Assistant
Department of Electrical and Computer Engineering
Sponsor: Secretary of the Air Force

OBJECTIVE: To conduct research into architectures and algorithms for the acquisition and processing of tactical information. To provide support for the course Space Systems 3001, Military Applications of Space and for SS4041 and SS4051, Military Space Systems and Technologies.

SUMMARY: The projects investigated: (1) algorithms and architectures of systems for the production, distribution, and analysis of tactical information; (2) architectures of spaceborne computer systems; (3) operational problems concerned with the employment of tactical information for decision making and targeting; (4) algorithms for radar pulse identification; hosting of a workshop on ocean surveillance at NPS in the Summer of 1997, and the inclusion of a major space system architecture study in SS4051 in Winter 1977 are being planned.

THESES DIRECTED:

Jamshidi, S.M., "Vulnerability Study of the Situational Awareness Beacon with Reply," Master's Thesis, Naval Postgraduate School, September 1996.

Pearson, S.C., "Simultaneous Probability of Detection of Certain Threat Emitters Using Multiple Collection Sources," Master's Thesis, Naval Postgraduate School, June 1996.

Randolph, M.D., "PCM Infrastructure Technologies," Master's Thesis, Naval Postgraduate School, September 1996.

Scott, R.E., "The Disadvantage of Digital Technology," Master's Thesis Naval Postgraduate School, September.

DoD KEY TECHNOLOGY AREAS: Space Vehicles

KEYWORDS: Military space applications, tactical support, ocean surveillance

SMALL SATELLITE DESIGN PROJECT
Kyle T. Alfriend, Navy TENCAP Chair Professor
Space Systems Academic Group
Herschel H. Loomis, Jr., Professor
Department of Electrical and Computer Engineering
Sponsor: Tactical Exploration of National Capabilities (TENCAP) Office

OBJECTIVE: To develop the design of a special purpose small satellite. To integrate the design experience with two courses taken by the Space Systems Engineering and Space Systems Operations students.

SUMMARY: Two consecutive courses treated the design of a small special purpose satellite, the first, designed a sensing payload, and the second, developed the architecture of the space and ground component and designed the spacecraft.

PUBLICATIONS:

Buck, N., et al., "RENEGADE Spacecraft Design ," AA Spacecraft Design Final Report, with Top Secret SCI Annex, June 1996.

Lunde, K., et al., "RENEGADE Payload Design ," EC4750, SIGINT Systems II Final Report, Top Secret SCI, June 1996.

THESES DIRECTED:

Lunde, K., "The Feasibility of Using Tethered Satellites for Geolocation," Master's Thesis, Naval Postgraduate School, September 1966.

Triska, N.E., "The Astrodynamics Problems of Digital TDMA Signal Detection," Master's Thesis Naval Postgraduate School, December 1996.

DoD KEY TECHNOLOGY AREAS: Space Vehicles

KEYWORDS: Tether satellites, remote sensing

RADIATION HARDENED SPACE BASED SOLAR CELLS AND ELECTRONIC DEVICES
Sherif Michael, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Research Laboratory

OBJECTIVE: To study the space radiation effects on state-of-the-art solar cells including GaAs and InP cells. To investigate annealing methods developed in previous NPS research on the recovery of radiation degraded performance of advanced space cells. Develop radiation hardened analog VLSI circuits for space applications.

SUMMARY: Continuation of the ongoing research on photovoltaic power technology. Research tasks include optimizing current annealing methods previously developed for GaAs cells. The tasks also include investigating of the new laser annealing technique on GaAs and InP solar cells. Irradiating solar cells using NPS linear accelerator, and measuring their characteristics using the newly developed solar simulator facilities. Other tasks are to investigate radiation effects on different electronic devices. Radiation testing of analog VLSI chips previously designed and fabricated using the NPS linear accelerator.

PUBLICATION:

Michael, S., "Programmable Sampled Data Filter with Low Sensitivity Implementation," Proceedings of the International Conference on Electronics, Rhodes, Greece, October 1996.

CONFERENCE PRESENTATION:

Michael, S., "Programmable Sampled Data Filter with Low Sensitivity Implementation," International Conference on Electronics, Rhodes, Greece, October 1996.

THESES DIRECTED:

Salsbury, D., "In-Situ Testing of Radiation Effects on VLSI Capacitors Using the NPS Linear Accelerator," Master's Thesis, Naval Postgraduate School, December 1996.

Boyer, L.L., "Power Recovery of Radiation Damaged MOCVD Grown Indium Phosphide on Silicon Solar Cells Through Argon-Ion Laser Annealing," Master's Thesis, Naval Postgraduate School, June 1996.

DoD KEY TECHNOLOGY AREAS: Electronics, Other (Spacecraft Design, Radiation Effects)

KEYWORDS: Radiation effects, radiation hardened electronics, VLSI, solar cells

DIRECT BROADCASTING SERVICES (DBS) FOR THE MOBILE WARRIOR
P.H. Moose, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Command, Control and Ocean Surveillance Center
and Naval Postgraduate School-Institute of Joint Warfare Analysis

OBJECTIVE: The main goal of this project is to determine the requirements for a direct broadcast service within the global broadcast system (GBS) architecture for mobile and deployed military units.

SUMMARY: During the current year, the Army, Navy, Air Force, and Marine Corps were surveyed to determine their need for GBS products to deployed and mobile units. All services except the Marine Corps viewed the mobile service as a high priority. Technical factors associated with delivering high data rate transmissions to users without fixed ground terminals were examined and various options were studied. It was concluded that a downlink testbed for GBS should be installed and instrumented to conduct experiments with a variety of potential solutions. Initial design, acquisition, and installation of the required equipment was begun during CY 1996. The project is continuing in CY 1997.

THESIS DIRECTED:

Carlisle, R.S., "A Global Broadcast Service for the User on the Move," Master's Thesis, Naval Postgraduate School, June 1996.

DoD KEY TECHNOLOGY AREAS: Command, Control and Communications

KEYWORDS: SATCOM, direct broadcast, wireless, communications

ELECTRO-MAGNETIC (EM) SIGNATURE SOURCE MEASUREMENT USING
SPATIAL SPECTRAL DOMAIN PROCESSING
Michael A. Morgan, Professor
Department of Electrical and Computer Engineering
Sponsor: Office of Naval Research

OBJECTIVE: There are three primary objectives of this research: 1) discover a comprehensive theory relating measured EM signatures and source spectral domain radiation contributions on general surfaces, 2) develop enhanced back-propagation algorithms for improved imaging of radiation sources, and 3) validate algorithms using both synthetic data from numerical simulations and measured data from the NPS scattering range and other providers.

Important technical issues involve discovery and development of the most useful technique for implementation with measured data. The form of this transformation is an issue, with integral equation and differential equation (e.g., finite element) based approaches possible, as well as hybrid methods. On-surface descriptions of signature sources can include physical currents or, more generally, equivalent currents (useful for apertures and volume sources such as penetrable composite materials). Algorithm robustness is a most important issue for real-world operation. Error propagation to source images induced by noise and inaccuracies in acquired data requires detailed quantification.

SUMMARY: This effort supports future ship survivability by furthering the evolution of measurement procedures and data processing for ship EM signature characterization. Accurate localization and identification of radiation sources from both scattering (RCS) and emitters is essential for their mitigation in the design, construction and maintenance of future low-observable platforms operating in an increasingly sophisticated enemy sensor environment.

PUBLICATION:

Morgan, M.A., "Electromagnetic Radiation Source Imaging," Project Report No. 1, Office of Naval Research, Code 334, August 1996.

DoD KEY TECHNOLOGY AREAS: Sensors

KEYWORDS: Imaging, back-propagation, diffraction limit

IMPULSE ANTENNA DESIGN
Michael A. Morgan, Professor
Department of Electrcal and Computer Engineering
Sponsor: Naval Research Laboratory

OBJECTIVE: The goal of this task is to investigate the impulse radiation characteristics of specified antenna structures.

SUMMARY: Initial wire-grid numerical modeling of antenna structures has been completed using frequency-stepping. Impulse source modeling has been approached independently from both frequency- and time-domains to form Thevenin equivalent circuits for impulsive sources. Responses from these distinct source models have been shown to agree. Impulse response characterization of antenna structures is accomplished via inverse transformation of an equivalent circuit.

PUBLICATION:

Morgan, M.A., "Pulse Excitation of Wire-Grid Antennas," Project Report No. 1, Naval Research Laboratory, May 1996.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation

KEYWORDS: Impulse response, antenna modeling, Thevenin equivalent

ULTRA-WIDEBAND IMPULSE ANTENNA DESIGN
Michael A. Morgan, Professor
R. Clark Robertson, Professor
Department of Electrical and Computer Engineering
Sponsor: United States Army Communications Electronics Command

OBJECTIVE: Goals of this project are to perform engineering designs, develop validation procedures, and to construct and test highly efficient, small-sized prototypical ultra-wideband impulse receiving antennas.

SUMMARY: A Method-of-Moments numerical model was developed as an aid to the design process. This numerical model was employed extensively to search for optimum geometrical dimensions and resistive tapers to achieve the challenging 10MHz operation criterion, given the antenna size constraint.

Several prototype TEM horns were then fabricated and performance evaluations were conducted using two procedures. Preliminary tests were performed in an anechoic chamber, using identical transmitting and receiving antennas,

with a low-power dc-50 GHz step-waveform source and a 50 GHz bandwidth sampling oscilloscope receiver. Open region tests were then conducted in a desert environment using a higher power impulse source radiating from a 10 foot diameter reflector with a conical TEM feed.

PUBLICATIONS:

Morgan, M.A., and Robertson, R.C., "Impulse Receiving Antenna Design and Measurement," Abstracts of URSI Radio Science Meeting, p. 215, July 1996.

Morgan, M.A., and Robertson, R.C., "Optimized TEM Horn Impulse Receiving Antenna," Abstracts of Ultra-Wideband, Short Pulse EM 3 Conference, p. 92, May 1996.

Morgan, M.A., and Robertson, R.C., "Optimized TEM Horn Impulse Receiving Antenna," in Ultra-Wideband, Short-Pulse Electromagnetics 3, L. Carin and L.B. Felsen, eds., Plenum Press, New York, (accepted).

CONFERENCE PRESENTATIONS:

Morgan, M.A., and Robertson, R.C., "Optimized TEM Horn Impulse Receiving Antenna," 3rd International Conference on Ultra-Wideband, Short-Pulse Electromagnetics, Albuquerque, NM, May 27-31 1996.

DoD KEY TECHNOLOGY AREAS: Sensors

KEYWORDS: Ultra-wideband, impulse antennas, TEM horns

<div align="center">

ULTRA-WIDEBAND IMPULSE SIGNAL PROPAGATION
Michael A. Morgan, Professor
R. Clark Robertson, Professor
Rama Janaswamy, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: United States Army Communications Electronics Command

</div>

OBJECTIVE: The goal of this project was development of a software package for use in estimating transient electromagnetic signals at a location near the signal source based on measurements of the signal at a different (generally more distant) location.

SUMMARY: A procedure was developed for predicting the waveshape of an ultra-wideband, impulsive electromagnetic signal at a specified location over a rough ground using measurements of the same signal at another location. Impulsive signals are transient signals of very short duration containing very high spectral content. The estimation procedure was developed by modeling the ground as homogeneous, conducting, non-permeable, half-space with a random surface. Using this model for the ground, frequency domain transfer functions relating fields at differing locations were developed for both horizontally and vertically polarized signals. The signal at a specified point can then be obtained via the inverse discrete Fourier transform of the product of the transfer function and the discrete Fourier transform of the measured impulsive signal. Locations of both the measured and the estimated signals must be in the far-field of the impulsive signal source. The transmitting antenna is assumed to be a circular reflector with an azimuthally symmetric aperture distribution. The estimation procedure was validated using a synthetic impulse signal and field tested using measured vertically polarized, impulsive signals.

PUBLICATIONS:

Robertson, R.C., Morgan, M.A., and Janaswamy, R., "Ultra-Wideband Impulse Propagation," Naval Postgraduate School Technical Report, NPS-EC-96-002, March 1996.

Robertson, R.C., Janaswamy, R., and Morgan, M.A., "Ultra-Wideband Impulse Propagation," Abstracts of Ultra-Wideband, Short Pulse EM 3 Conference, p. 260, 1996.

Robertson, R.C., Morgan, M.A., and Janaswamy, R., "Ultra-Wideband Impulse Propagation," in Ultra-Wideband, Short-Pulse Electromagnetics 3, L. Carin and L.B. Felsen, eds., Plenum Press, New York (accepted).

CONFERENCE PRESENTATION:

Robertson, R.C., Janaswamy, R., and Morgan, M.A., "Ultra-Wideband Impulse Propagation," 3rd International Conference on Ultra-Wideband, Short-Pulse Electromagnetics, Albuquerque, NM, 27-31 May 1996.

DoD KEY TECHNOLOGY AREAS: Sensors

KEYWORDS: Ultra-wideband, impulse, propagation

HIGH RESOLUTION DIRECT DIGITIZATION AND OPTICAL TELEMETRY OF ANTENNA SIGNALS
Phillip E. Pace, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Space and Naval Warfare Systems Command

OBJECTIVE: The main objective of this experimental hardware project is to digitize HF signals directly at the antenna (digital antenna) by using high-speed optical signal processing and high-resolution digital electronics. The goal is to develop a prototype that will digitize an antenna signal using a sampling frequency of 5 mega-samples per second to achieve a 14-bit representation of the input.

SUMMARY: The digital antenna architecture is based on the optimum symmetrical number system (OSNS) which decomposes the amplitude analyzing operation into a number of less complex sub-operations to achieve high accuracy. The process uses only 253 GaAs comparators to achieve 14-bits of accuracy. The architecture has three optical channels at the front end antenna interface (modulus 63, 64 and 65) and four comparator boards (1 board per channel and 1 board for error correction). Each comparator board has 64 comparators. Each comparator matching threshold voltage is supplied by a unique 13-bit DAC. The four, 7-bit binary outputs from the comparator boards are recombined using a field programmable gate array in order to render the 14-bit output word and perform interpolation signal processing when a possible error is present. The hardware construction is complete and is now going through a series of static and dynamic tests to determine the effective number of bits, the spurious free dynamic range, the transfer function, the integral and differential non-linearity. In addition, other high resolution digital antenna architectures have been investigated such as optical sigma-delta modulation at the antenna.

PUBLICATIONS:

Pace, P.E., "14-Bit 5 MHz Digital Antenna : Electro-Optical Digitizer and Hardware Realization," Naval Postgraduate School Technical Report, NPS-EC-96-011, August 1996.

Pace, P.E., Leino, R.E., and Styer, D., "Use of the Symmetrical Number System in Resolving Single-Frequency Under-Sampling Aliases," IEEE Transactions on Signal Processing, (accepted).

Pace, P.E., Ying, S.J., Powers, J.P., and Pieper, R.J., "Integrated Optical Sigma-Delta Modulators," Optical Engineering, Vol. 35, pp. 1828-1836, July 1996.

CONFERENCE PRESENTATIONS:

Pace, P.E., and Patterson, R., "Wideband Opto-Electronic 14-Bit SNS A/D Converter," presentation to the Space and Naval Warfare Systems Command, San Diego, CA, 7 March 1996.

THESES DIRECTED:

Hart, T.L., "Analysis and Design of CMOS Voltage Folding Circuits and Their Use in High-Speed ADCs," Master's Thesis, Naval Postgraduate School, June 1996.

Leino, R.E., "Use of the Symmetrical Number System in Resolving Undersampling Aliases," Master's Thesis, Naval Postgraduate School, September 1996.

Park, B.-J., "Interpolation Techniques in High Resolution Residue Antenna Architectures," Master's Thesis, Naval Postgraduate School, September 1996.

Pietruszewski, A., "A Programmable Offset Differential ECL Four Channel Clock Generator for Applications in High Resolution Digital Antennas," Master's Thesis, Naval Postgraduate School, September 1996.

Rodriques, L.E.M., "High-Resolution Residue Antenna Architectures for Wideband Direction Finding," Master's Thesis, Naval Postgraduate School, June 1996.

OTHER:

Pace, P.E., and Styer, D., "High-Resolution Encoding Process with Robust Gray Code Properties for Folding ADCs, NC77837, Patent application filed 19 June 1996.

DoD KEY TECHNOLOGY AREAS: Electronic Warfare, Battlespace Environments

KEYWORDS: Optimum symmetrical number system, digital antennas, information warfare

CORRELATION OF ALGORITHMS OF SHIPBOARD COUNTERMEASURES (ASCM) SIMULATOR CAPTIVE-CARRY EXPERIMENTAL RESULTS
Phillip E. Pace, Associate Professor
Department of Electrical and Computer Engineering
Sponsor : Naval Research Laboratory

OBJECTIVE: The objective of this project was to develop a new class of modeling and simulation algorithms that allow an accurate miss distance to be calculated from a high-bandwidth electronic attack captive-carry test result.

SUMMARY: The techniques combine the results from each test configuration and represent an improvement in evaluating an electronic attack effectiveness over a singly independent analysis. Anechoic chamber and captive-carry test results from a hardware-in-the-loop anti-ship missile simulator are being used to demonstrate the algorithms and detail the feasibility of the approach. An investigation into using the techniques for the test and evaluation of air-to-air missile simulators is also being conducted.

PUBLICATIONS:

Pace, P.E., "P-3 Captive-Carry Correlation (P3C3)-CHARLIE: Description and EW Flight Test Results Against the SLQ-32," Naval Postgraduate School Technical Report, NPS-EC-96-007, April 1996.

Pace, P.E., Sharp, K.C., and Morris, W.M., "ASCM Simulator Correlation Processor Bandwidth Considerations in Evaluating Effectiveness of Electronic Attack ," Proceedings of the 41st Annual Joint Electronic Warfare Conference, Monterey, CA, May 1996.

Pace, P.E., Nishimura, B.H., Morris, W.M., and Surratt, R.E., "Effectiveness Calculations in HIL Missile Simulator Experiments," IEEE Transactions on Aerospace and Electronic Systems, (accepted).

Schleher, D.C., and Pace, P.E., "Support Jamming Effectiveness: Comparison of Direct Digital Synthesis and RF Memory Exciter Techniques ," Proceedings of the 41st Annual Joint Electronic Warfare Conference, Monterey, CA, May 1996.

CONFERENCE PRESENTATIONS:

Pace, P.E., "Center for Joint Services Electronic Warfare Overview and Research in Ships Self Defense," JDL-TPEW C3 CM Subpanel, Naval Postgraduate School, 6 February 1996.

Pace, P.E., "Introduction to the Center for Joint Services Electronic Warfare and Tour of Facilities," NATO Defense Research Group AC243 Panel 9, 45G10, Electronic Support Measures 24th Meeting, 18 March 1996.

Pace, P.E., "Introduction to the Center for Joint Services Electronic Warfare and Tour of Facilities," Navy's Simulator Validation Working Group, Monterey, CA, 31 January 1996.

THESES DIRECTED:

Gill, C.W., "Neural Prediction of Missile Dynamics During Hardware in the Loop Captive-Carry Experiments," Master's Thesis, Naval Postgraduate School, September 1996.

Rowe, A.W., "Distributed Time-Space-Position Information Systems for Captive-Carry Experiments," Master's Thesis, Naval Postgraduate School, December 1996.

Sharp, K.C., "Improvements in the P3C3 Threat Simulator Model Development Environment," Master's Thesis, Naval Postgraduate School, September 1996.

Watson, J., "A Comparison of DDS and DRFM Techniques in the Generation of Smart Noise Jamming Waveforms," Master's Thesis, Naval Postgraduate School, September 1996.

DoD KEY TECHNOLOGY AREAS: Electronic Warfare

KEYWORDS: Hardware in the loop missile simulators, effectiveness calculations

AUTOMATIC EXTRACTION OF THREAT CRITICAL PARAMETERS FROM ALGORITHMS OF SHIPBOARD COUNTERMEASURES (ASCM) CHARACTERIZATION EXPERIMENTS
Phillip E. Pace, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Research Laboratory

OBJECTIVE: The objective of this project is to further develop and maintain the Automatic Extraction of Threat Simulator Critical Parameters (AETSCP) software program in use by the Naval Research Laboratory. The AETSCP is a MATLAB software engineering project that automatically extracts a set of Electronic Warfare Integrated Re-programmable (EWIR) database parameters from hardware-in-the-loop missile simulator characterization experiments (performed in the NRL Central Target Simulator Facility). The parameters are extracted and automatically compared to the threat database in order to determine how closely the simulator performs compared to the actual threat weapon system.

SUMMARY: The AETSCP software is currently at version 1.2 and processes characterization data formats V1 and V2. The AETSCP software has been used to extract results to validate the SIM7 and INDIA hardware-in-the-loop threat missile simulators. Currently, AETSCP version 1.2 is being used to validate the LIMA simulator. The software is being updated to version 2.0 to be compatible with characterization data format V1, V2 and V3.

CONFERENCE PRESENTATION:

Pace, P.E., and Zulaica, D., "The Automatic Extraction of Threat Simulator Critical Parameters Version 1.0 ," Navy Unique Threat Simulator Validation Working Group, Naval Postgraduate School, January 1996.

OTHER:

Pace, P.E., "AETSCP : Program for the Automatic Extraction of Simulator Threat Critical Parameters Version 1.2," developed for the US Navy Unique Simulator Validation Working Group (MATLAB software program).

DoD KEY TECHNOLOGY AREAS: Electronic Warfare

KEYWORDS: Threat missile simulators, EWIR parameter database, validation

EXTENDING THE VISIBILITY MINIMUM RESOLVABLE TEMPERATURE DIFFERENCE (MRTD) MODEL TO SECOND GENERATION THERMAL IMAGING SYSTEMS
R.J. Pieper, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Postgraduate School

OBJECTIVE: To develop both analytic guidelines and the corresponding computer code which would extend the basic concepts for the first generation visibility model so that MRTDs for second generation thermal imaging systems could be predicted.

SUMMARY: A new model is presented for predicting the MRTD performance of second generation thermal imaging systems based on minimum input contrast, and a contrast reduction factor due to aliasing and blurring effects. The model makes no assumptions regarding the recognition process, which allows for a separate threshold value to be defined for either a human or machine observer. The model incorporates aliasing concepts and extends performance prediction beyond the nominal Nyquist rate of the system. The model's predictions are compared to the prediction of the current standard FLIR92 model and measured results from laboratory focal plane array imaging systems. A scheme for performing laboratory objective MRTD performance tests is proposed and tested.

PUBLICATION:

Pieper, R.J., "A Second Generation Visibility Based Model for Objective/Subjective FLIR MRTD," ERIM Proceedings for the 1996 IRIS Specialty Group on Passive Sensors, 1996.

CONFERENCE PRESENTATION:

Pieper, R.J., "A Second Generation Visibility Based Model for Objective/Subjective FLIR MRTD," 1996 IRIS Specialty Group on Passive Sensors, Monterey, CA, 13 March 1996.

DoD KEY TECHNOLOGY AREAS: Electronics, Modeling and Simulation, Sensors

KEYWORDS: Thermal imaging, performance measure

DUAL BASELINE TRIANGULATION

R.S. Pieper, Associate Professor
Department of Electrical and Computer Engineering
Alf Cooper, Professor
Department of Physics
Sponsors: Johns Hopkins University, Applied Physics Laboratory and
Naval Sea System Command

OBJECTIVE: Despite the disadvantages of active radar, modern combat stems (AEGIS and FAAD) are typically built around active radar target detection and tracking. It has been recognized that ESM IR and TV sensors are capable of providing useful inputs to such systems, particularly for application for low flying targets to be tracked in from the horizon. In this environment passive IR sensor with their greater range of detection show significant advantages. For combat systems the target designation and response must be based on the cooperative use of data from dissimilar sensors. This requires that simultaneous data from these sensors must be compatible for system use. While a passive IR system can provide detection and pointing precision advantages over that available with active radar, the complimentary use of both systems will generally be useful for target identification. In addition, the more extensive time requirement for radar scanning to detect a remote target also supports the need for a complementary system. The passive IR system can not only provide advance data on detecting targets as they appear on the horizon but also range information in order to assess the urgency of the fire control problem. This project addresses one approach to the provision of target range information by cooperative use of two or more passive sensors.

SUMMARY: A new method for IR passive ranging based on the principle of triangulation has been considered. The proposed orthogonal dual baseline scheme eliminates the well known geometric dilution effect, inherent in single baseline methods. The performance of each of the two orthogonal baselines depends on target orientation and limitations in the precision in the bearing measurements. A general expression, involving both baselines, for the maximum triangulation range is derived as a function of polar angle measured relative to the center of the dual baseline system. Limitations in the dual baseline model due to the geometrically assessed optical horizon are also considered.

PUBLICATION:

Pieper, R., Cooper, A., and Pelegris, G., "Passive Range Estimation Using Dual Baseline Triangulation," Optical Engineering, Vol. 35, pp. 685-692, 1996.

DoD KEY TECHNOLOGY AREAS: Electronic Warfare, Sensors, Surface/Under Surface Vehicles - Ships and Watercraft

KEYWORDS: Range estimation, triangulation

DIGITAL SPREAD SPECTRUM COMMUNICATION SYSTEMS

R. Clark Robertson, Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Surface Warfare Center-Dahlgren Division

OBJECTIVE: At the conclusion of this course, participants will be able to do elementary link budget analyses and signal-to-noise ratio computations, will understand the advantages and disadvantages of various M-ary digital communication systems, will understand the concepts of diversity and forward error correction coding, will have a basic understanding of spread spectrum communications, and will know which digital signaling schemes are used in modern Navy and DoD communication systems.

SUMMARY: The effect of wideband (benign) noise and narrowband (usually hostile jamming) interference on the design of digital communication systems was examined. Specific topics included link budget analysis, signal-to-noise

ratio calculations, the performance of various digital modulation schemes in both benign and hostile noise environments, bandwidth and implementation trade-offs, power requirements, spread spectrum techniques, forward error correction coding, and carrier and data synchronization methods. Examples of military communication systems were presented.

OTHER:

Robertson, R.C., "Digital-Spread Spectrum Communication Systems," notebook developed for short course at NSWC-DD, 20-22 November 1996.

DoD KEY TECHNOLOGY AREAS: Command, Control and Communications

KEYWORDS: Digital communications, frequency-hopping, direct sequence, spread spectrum

SONAR SIGNAL MODELING
Charles W. Therrien, Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Undersea Warfare Center-Newport Detachment

OBJECTIVE: This research involves the development of models for underwater signals received by a passive sonar, to support work in classification. The research is part of a continuing project begun in 1992.

SUMMARY: The work for 1996 focused on improving the ability to remove noise from passive sonar data. Removing ambient noise from the data has the potential to improve the performance of both sonar operators (through listening) and automatic classifiers. However any distortions to the signal or artifacts introduced by the noise removal processing can lead to difficulties, especially in training automatic classifiers, and need to be well understood. This in particular, was a focal point for the work in 1996.

The work for FY96 began with a theoretical analysis of the Wiener filter, which is the basis for the noise removal algorithm developed for NUWC in an earlier year and is currently being evaluated in the 6.2 program with possible transition to 6.3. The theoretically optimal IIR filter was compared for this problem and the IIR filter on which the practical noise removal algorithms is based. The results establish bounds on the performance that can be achieved by any IIR or FIR filter and are presented as a family of curves that depend on input SNR and correlation of the input signal. Signal distortion introduced by the algorithm was also studied and produced curves that show signal distortion as a function of input SNR and correlation of the input signal.

The results developed in this investigation serve not only to characterize the performance of an existing noise removal algorithm, but should serve as a standard by which to compare other algorithms.

CONFERENCE PRESENTATION:

Therrien, C.W., "Optimal Filtering for Removing Noise in Passive Sonar Data," ONR Peer Review, Austin, TX, 24-26 September 1996.

DoD KEY TECHNOLOGY AREAS: Other (Electronic Devices)

KEYWORDS: Sonar signal processing, acoustic data modeling, noise removal

BEARTRAP POST-MISSION ANALYSIS SYSTEM
Murali Tummala, Associate Professor
Charles W. Therrien, Professor
Department of Electrical and Computer Engineering
Sponsor: Advanced Maritime Projects Office

OBJECTIVE: To design and develop a signal processing system capable of implementing narrowband frequency tracking, multi-target tracking, wideband and swath processing, transient analysis, and data fusion for the Beartrap post-mission analysis.

SUMMARY: The system is being developed based on commercial off the shelf technology: PentiumPro based PC with Windows NT operating system. The user interface is being developed using Microsoft Visual C++, and all the processing algorithms are being coded in C language.

During 1996, initial system design requirements have been developed, with sponsor's approval. Both hardware and software interface designs have been developed and partially implemented. The narrowband analysis software (AQL) modules have been developed in MATLAB to carryout filter and decimation, multi-target tracking, and frequency track estimation functions. Some of the functions have been converted to C language for ultimate porting to the DSP hardware system based on SHARC DSP processors. Work is initiated on sound pressure level estimation algorithms as well as transient analysis algorithms.

PUBLICATION:

Tummala, M., Therrien, C.W., and Shields, M.K. "A New Look: Beartrap Post-Mission Analysis System Initial System Design," Naval Postgraduate School Technical Report, NPS-EC-96-014, October 1996.

DoD KEY TECHNOLOGY AREAS: Sensors, Computing and Software, Human Systems Interface, Surface/Under Surface Vehicles - Ships and Watercraft

KEYWORDS: Signal processor design, acoustic signal processing, graphical user interface design

PREDISTORTION TECHNIQUES FOR HIGH POWER AMPLIFIERS
Murali Tummala, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Command, Control and Ocean Surveillance Center

OBJECTIVE: To develop new techniques for predistortion of high power amplifiers used in line of sight wireless links. Earlier effort was based on neural network and polynomial approximation methods.

SUMMARY: During 1996, a Volterra series based algorithm was developed to directly estimate the inverse power amplifier model parameters, which are then used to realize the predistortor. Experiments are conducted to test the order of nonlinearity and the depth of memory needed to satisfactorily compensate the power amplifier nonlinear behavior. TWT amplifiers and QAM are being considered at this point.

PUBLICATIONS:

Tummala, M., Donovan, M., Watkins, B., and North, R., "Predistortion of High Powered Amplifiers Using Inverse Volterra Modeling," accepted for publication in Proceedings of 1997 IEEE International Conference on Acoustics, Speech, and Signal Processing, Munich, Germany, 21-24 April 1997.

Watkins, B.E., North, R., and Tummala, M., "Model Based Neural Network Predistortion of Nonlinear Amplifiers," Proceedings of World Congress on Neural Networks, San Diego, CA, 15-20 September 1996.

Watkins, B.E., North, R., and Tummala, M., "Predistortion of Nonlinear Amplifiers Using Neural Networks," Proceedings of MILCOM-96, McLean, VA, pp. 316-320, 21-24 October 1996.

CONFERENCE PRESENTATIONS:

Watkins, B.E., North, R., and Tummala, M., "Model Based Neural Network Predistortion of Nonlinear Amplifiers," World Congress on Neural Networks, San Diego, CA, 15-20 September 1996.

Watkins, B.E., North, R., and Tummala, M., "Predistortion of Nonlinear Amplifiers Using Neural Networks," MILCOM-96, McLean, VA, 21-24 October 1996.

THESIS DIRECTED:

Donovan, M., "A Volterra Series Based Technique for High Power Amplifier Predistortion," Master's Thesis, Naval Postgraduate School, December 1996.

DoD KEY TECHNOLOGY AREAS: Sensors, Command, Control and Communications

KEYWORDS: High power amplifiers, wireless communications, predistortion

DATA FUSION ALGORITHMS FOR VESSEL TRAFFIC SYSTEM
Murali Tummala, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: U.S. Coast Guard

OBJECTIVE: To develop data fusion algorithms based on fuzzy association techniques for use in USCG vessel traffic system upgrade project.

SUMMARY: Vessel Traffic System (VTS) receives data from multiple sensors of different types: multiples radars, differential global positioning system based ADS receivers, acoustic sensors, and synthetically generated standard routes. Multiple sensors tracking the same target generate a large amount of redundant data. Here we have developed fuzzy association based algorithms to fuse data from multiple sensors. The software developed will be used in the VTS package which is based on JMCIS. AY97 may be the last year for this project.

PUBLICATIONS:

Tummala, M., Glenn, I., and Midwood, S., "Multisensor Data Fusion for the Vessel Traffic System," Naval Postgraduate School Technical Report, NPS-EC-96-015, October 1996.

Tummala, M., Midwood, S., and Glenn, I., "Multisensor Data Fusion Using Fuzzy Associative Techniques," submitted for review, Proceedings of 1997 IEEE International Symposium on Circuits and Systems, June 1997.

DoD KEY TECHNOLOGY AREAS: Command, Control and Communications, Sensors

KEYWORDS: Data fusion, fuzzy logic, multiple sensors

WIDEBAND SIGNAL ANALYSIS TECHNIQUES FOR ELECTROMAGNETIC TRANSIENT WAVEFORM ANALYSIS
Murali Tummala, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Air Warfare Center-Patuxent River

OBJECTIVE: To develop algorithms for analysis and synthesis of electromagnetic transient waveforms encountered in aircraft testing for radiation hardness evaluation.

SUMMARY: Wideband waveform analysis techniques based on multirate filters, wavelets, and the Fourier transform have been developed to analyze electromagnetic transient waveform data. Work involved dividing a given waveform into sub-band signals and combining sub-band signals belonging to waveforms measured from different aircraft orientations. The task required concatenating the low frequency and the high frequency measurements and combining horizontally and vertically polarized test waveforms to obtain a synthetically generated test drive waveform.

CONFERENCE PRESENTATION:

Frazier, S., Parimuha, E., Tummala, M., Winnenberg, T.F., and Martin, C.E., "Waveform Bounding and Combination Techniques for Inductively Coupled Direct Drive Testing," HART Conference, June 1996.

PUBLICATION:

Tummala, M., and Jeong, S., "Wideband Signal Analysis for Electromagnetic Transient Waveforms," Naval Postgraduate School Technical Report, NPS-EC-96-013, September 1996.

THESIS DIRECTED:

Jeong, S., "Wideband Signal Analysis and Synthesis Applied to Electromagnetic Transient Waveforms," Master's Thesis, Naval Postgraduate School, March 1996.

DoD KEY TECHNOLOGY AREAS: Sensors, Electronic Warfare

KEYWORDS: Electromagnetic transients, Fourier transform, multirate filtering

LORAN-C: CALOC AND CASUALTY CONTROL
Murali Tummala, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: U.S. Coast Guard

OBJECTIVE: To develop algorithms for estimation and control of phase delay in LORAN-C receivers to replace the existing CALOC system.

SUMMARY: This work is part of Coast Guard's Loran-C re-engineering effort, both transmitter and receiver circuits. Currently developing algorithms for improved estimates of phase delay in the receiver to replace the existing algorithm (called CALOC).

DoD KEY TECHNOLOGY AREAS: Command, Control and Communications

KEYWORDS: Phase delay, PID controller, Kalman filter

COMMUNICATIONS VULNERABILITY TO JAMMING
D.v.Z. Wadsworth, Senior Lecturer
Department of Electrical and Computer Engineering
Sponsor: Naval Security Group and Chief of Naval Operations

OBJECTIVE: The primary goal is to model the vulnerability of selected (blue) RF tactical communications links to both conventional and "smart" jamming. The 1996 effort is an unfunded continuation of research supported by the same sponsors during 1994 and 1995.

SUMMARY: During 1996, a mathematical model of the antijam performance of the Navy Tactical Data Information Link 4-C was completed. This model applies to the noncoherent detection of CW-pulse and linear chirp signals in a broadband noise jamming environment. The receiver model consists of an IF filter matched to a Gaussian-envelope pulse, a square-law device, a lowpass Gaussian video filter, and threshold decision detection of the sampled output. By including an arbitrary video bandwidth, the 1996 model provides significantly higher-fidelity antijam performance estimation than an earlier model (NPS-EC-95-012). The detailed analysis leading to the improved model is documented in two parts, NPS-EC-97-002 and a subsequent report.

PUBLICATION:

Wadsworth, D.v.Z., "Communications Performance Model for Navy Link 4C," Naval Postgraduate School Technical Report, NPS-EC-96-002, December 1996.

DoD KEY TECHNOLOGY AREAS: Command, Control and Communications, Electronic Warfare

KEYWORDS: Communications, electronic warfare

HIGH PERFORMANCE, RADIATION HARDENED INTEGRATED CIRCUIT TECHNOLOGY
Todd R. Weatherford, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Postgraduate School

OBJECTIVE: The goal of this project is to understand the response of state-of-the-art electronic technologies for use in military and space environments.

SUMMARY: This ongoing program is investigating measurement and computer simulation of high energy radiation (i.e., cosmic rays, alpha particles, etc.) induced photo currents in the latest DoD relevant high speed digital technologies. By using high speed optical sampling techniques we are measuring sub-picosecond resolution current transients in situ to an integrated circuit. These measurements are being analyzed with 2-D and 3-D computer simulation to understand charge transport internal to the transistor structure.

PRESENTATION:

Ledbetter, E.J., Weatherford, T.R., Whitaker, J.F., Ohm, J., and Fouts, D., "Sub-Picosecond Resolution Measurements of SEU-like Photocurrents in situ to an Active Integrated Circuit," submitted to IEEE Nuclear and Radiation Effects Conference for presentation in July 1997.

DoD KEY TECHNOLOGY AREAS: Space Vehicles, Battlespace Environments, Electronics, Electronic Warfare, Material, Processes and Structures

KEYWORDS: Solid state electronics, solid state physics, space electronics, radiation hardened ICs, single-event upset

PROJECT SUMMARIES

LT GaAs INTEGRATED CIRCUITS DEVELOPMENT
Todd R. Weatherford, Assistant Professor
Douglas J. Fouts, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Research Laboratory

OBJECTIVE: Develop radiation-hardened GaAs integrated circuits with low-temperature grown GaAs buffer layers.

SUMMARY: This program has developed test structures to investigate charge collection and single event upset in digital GaAs ICs. Work has focused on developing the proper parameter of molecular beam epitaxy wavers that are compatible with present commercial GaAs processes.

PUBLICATIONS:

Weatherford, T.R., Marshall, P.W., Dale, C., McMorrow, D., Peczalski, A., Baier, S., Carts, M., and Twigg, M., "Soft Error Immune LT GaAs ICs," 1996 IEEE GaAs IC Symposium Technical Digest.

McMorrow, D., Weatherford, T.R., Buchner, S., Knudsen, A.R., Melinger, J.S., Tran, L.H., and Campbell, A.B., "Single-Event Phenomena in GaAs Devices and Circuits," IEEE Transactions on Nuclear Science, Vol. 43, No. 2, April 1996.

CONFERENCE PRESENTATIONS:

Weatherford, T.R., Marshall, P.W., Dale, C., McMorrow, D., Peczalski, A., Baier, S., Carts, M., and Twigg, M., "Soft Error Immune LT GaAs ICs," 1996 IEEE GaAs IC Symposium, 6 November 1996.

Weatherford, T.R., Marshall, P.W., Dale, C., Peczalski, A., Baier, S., McMorrow, D., Dietrich, H., and Twigg, M., "Soft Error Results on Honeywell C-HIGFET ICs on LT GaAs Buffers," 1996 SEU Symposium, Los Angeles, CA, 17 April 1996.

Weatherford, T.R., Marshall, P.W., Dale, C., Peczalski, A., Baier, S., McMorrow, D., Dietrich, H., and Twigg, M., "Soft Error Results on Honeywell C-HIGFET ICs on LT GaAs Buffers," 1996 LT GaAs Workshop, Santa Barbara, CA, 7 March 1996.

DoD KEY TECHNOLOGY AREAS: Electronics

KEYWORDS: Integrated circuits, materials

DEVELOPMENT OF COOPERATIVE CONTROL ALGORITHMS FOR A MULTI-ROBOT SYSTEM
Xiaoping Yun, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Postgraduate School

OBJECTIVE: The goal of this project is to investigate modeling, control, and coordination of multiple mobile robotic systems.

SUMMARY: Given a group of mobile robots (say, 20 robots) randomly placed on a laboratory floor, how would one control them to form a geometric pattern such as a circle without using a centralized coordinator? This is the formation problem of distributed mobile robots investigated in this project. Distributed robots make motion plans based on a given task goal of the group and the perceived information about their environment from onboard sensors without the aid of a centralized coordinator. The formation problem of distributed mobile robots was studied in the literature for idealized robots. Idealized robots are able to instantaneously move in any directions, and are equipped with perfect range sensors. The focus of this project was to study the formation problem of distributed mobile robots that are subject

to physical constraints. Mobile robots considered in this project have physical dimensions and their motions are governed by physical laws. They are equipped with sonar and infrared range sensors. The formation of lines and circles was investigated in detail. It was demonstrated that line and circle algorithms developed for idealized robots do not work well for physical robots. New line and circle algorithms, with consideration of physical robots and sensors, were developed and validated through extensive simulations.

PUBLICATIONS:

Yun, X., Alptekin, G., and Albayrak, O., "Line and Circle Formation of Distributed Physical Mobile Robots," Journal of Robotic Systems, (accepted).

THESES DIRECTED:

Albayrak, O., "Line and Circle Formation of Distributed Autonomous Mobile Robots with Limited Sensor Range," Master's Thesis, Naval Postgraduate School, June 1996.

Alptekin, G., "Geometric Formation with Uniform Distribution and Movement in Formation of Distributed Mobile Robots," Master's Thesis, Naval Postgraduate School, June 1996.

DoD KEY TECHNOLOGY AREAS: Sensors, Ground Vehicles, Modeling and Simulation

KEYWORDS: Mobile robots, coordination, formation

COORDINATION OF MOBILE MANIPULATORS
Xiaoping Yun, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: National Science Foundation

OBJECTIVE: The objective of this project is to investigate control algorithms for coordinating locomotion and manipulation of mobile manipulators.

SUMMARY: A mobile manipulator consisting of a mobile platform and a manipulator combines the dextrous manipulation capability offered by a multi-link manipulator and the mobility provided by a mobile platform. Integration of a manipulator and a mobile platform, however, gives rise to many new issues. In this project, a family of control algorithms were developed for coordinating locomotion and manipulation, based on a novel concept of the preferred operating regions. These algorithms were implemented on an experimental mobile manipulator and shown to be very effective in performing various tasks. Dynamic interactions between a mobile platform and its onboard manipulator were investigated. The effect of dynamic interactions on tracking accuracy was obtained. Criteria were established for proper compensation of interactive forces with respect to task requirements. Using superduadric potential functions, an obstacle avoidance scheme for mobile manipulators was developed and integrated with coordinated control algorithms. A control algorithm for coordinating two mobile manipulators was also developed and tested on an experimental system.

PUBLICATIONS:

Sarkar, N., Yun, X., and Kumar, V., "Dynamic Control of 3-D Rolling Contacts in Two-Arm Manipulation," accepted for publication in IEEE Transactions on Robotics and Automation, October 1996.

Yamamoto, Y., and Yun, X., "A Modular Approach to Dynamic Modeling of a Class of Mobile Manipulators," accepted for publication in International Journal of Robotics and Automation, October 1996.

Yamamoto, Y., and Yun, X., "Effect of the Dynamic Interaction on Coordinated Control of Mobile Manipulators," IEEE Transactions on Robotics and Automation, Vol. 12, No. 5, pp. 816-824, October 1996.

Yamamoto, Y., and Yun, X., "Stability Analysis of a Mobile Manipulator Under Force Control," accepted for publication in Advanced Robotics, May 1996.

Yamamoto, Y., Eda, H., and Yun, X., "Coordinated Task Execution of a Human and a Mobile Manipulator," Proceedings of 1996 IEEE International Conference on Robotics and Automation, Minneapolis, MN, pp. 1006-1011, April 1996.

Yun, X., and Sarkar, N., "Dynamic Feedback Control of Vehicles with Two Steerable Wheels," Proceedings of 1996 IEEE International Conference on Robotics and Automation, Minneapolis, MN, pp. 3105-3110, April 1996.

Yun, X., and Yamamoto, Y., "Stability Analysis of the Internal Dynamics of a Wheeled Mobile Robot," accepted for publication in Journal of Robotic Systems, December 1996.

CONFERENCE PRESENTATION:

Yun, X., "Dynamic Feedback Control of Vehicles with Two Steerable Wheels," 1996 IEEE International Conference on Robotics and Automation, Minneapolis, MN, April 1996.

THESIS DIRECTED:

Tan, K.-C., "Motion Planning and Dynamic Control of the Nomad 200 Mobile Robot in a Laboratory Environment," Master's Thesis, Naval Postgraduate School, June 1996.

DoD KEY TECHNOLOGY AREAS: Sensors, Ground Vehicles, Modeling and Simulation

KEYWORDS: Mobile manipulators, coordination, control

COMPUTER INSTRUMENTATION FOR SCIENCE AND ENGINEERING RESEARCH INSTRUMENTATION: EXPERIMENTAL STUDY OF MULTIPLE MOBILE MANIPULATORS
Xiaoping Yun, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: National Science Foundation

OBJECTIVE: The objective of this project is to study force and motion control of robot manipulators for intelligent exploration of environments.

SUMMARY: For a robotic system to function in an unstructured environment, it must be able to explore the environment and automatically generate a model of the environment. The exploration can not be accomplished by noncontact sensing modalities alone. It requires direct interaction of the robot with the environment, i.e., touching objects and surfaces in the environment. Simultaneous motion and force control is essential for a robot to actively interact with the environment. Exploration tasks involve transition from unconstrained to constrained motion marked by the contact with a constrained surface. This phenomenon divides the task into more than one control strategies plagued with control discontinuities. This project seeks to design a controller which avoids such discontinuity. The principle is based on the analysis of impulsive constraints. It is shown that such discontinuity can be avoided by modeling the cause of the force discontinuity of the end-effector as the velocity discontinuity of the constraint surface as opposed to the discontinuity of the Lagrange multiplier. This velocity discontinuity can then be dealt with by a continuous control strategy. A controller is designed based on this principle. Input-output linearization is performed to linearize and decouple the system. The effectiveness of this new approach has been demonstrated by computer simulations and physical experiments.

PROJECT SUMMARIES

PUBLICATIONS:

Sarkar, N., and Yun, X., "Design of a Continuous Controller for Contact Transition Task Based on Impulsive Constraint Analysis," Proceedings of 1996 IEEE International Conference on Robotics and Automation, Minneapolis, MN, pp. 2000-2005, April 1996.

Sarkar, N., and Yun, X., "A Novel Approach to the Design of a Continuous Controller for Contact Transition Tasks," submitted to <u>IEEE Transactions on Robotics and Automation</u>, June 1996.

Sarkar, N., Kumar, V., and Yun, X., "Velocity and Acceleration Analysis of Contact Between Three-Dimensional Rigid Bodies," Transactions of the ASME, <u>Journal of Applied Mechanics</u>, Vol. 63, No. 4, pp. 974-984, December 1996.

Yun, X., and Sarkar, N., "A Unified Formulation of Robotics Systems with Holonomic and Nonholonomic Constraints," submitted to <u>IEEE Transactions on Robotics and Automation</u>, December 1996.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Other (Robotic Technology)

KEYWORDS: Robot manipulators, force control, impulsive constraints

DEVELOPMENT OF A SEMI-AUTONOMOUS ROBOTIC SYSTEM FOR MINE/UNEXPLODED ORDINANCE (UXO) DETECTION AND CLEARING
Xiaoping Yun, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Postgraduate School-Institute for Joint Warfare Analysis

OBJECTIVE: The objective of this project is to investigate and develop a semi-autonomous robotic system for land mines and UXO detection. The emphasis is on integration of land vehicles and detection sensors.

SUMMARY: There are more than 100 million land mines scattered around the world in more than 60 countries. These land mines kill about 10,000 and injure another 20,000 people (many of them are children) every year. There are also millions of acres of land in the United States and other countries contaminated with unexploded ordnance (UXO) as a result of testing and training in the past. The contaminated land must be cleared inch by inch before transferring to civilian use. At Fort Ord, the clearing process is carried out by trained engineers with a hand-held probe. Current methods for clearing unexploded ordnance are labor-intensive, hazardous, and costly. The use of unmanned vehicles greatly reduces the danger to the personnel involved. At the same time, unmanned vehicles offer other advantages as well. Humans have a limited attention span. Searching a large field such as Fort Ord is a repetitive and tiresome task. The accuracy of searching by humans will inevitably depend on the degree of concentration. A robotic system is ideally suited for such a repetitive and boring task (aside from safety concerns). The robotic system is not subject to fatigue and degradation of attention, and thus provides uniform accuracy in searching tasks. This is a multi-year project. This year's effort is focused on developing a prototype four-wheel-drive and four-wheel-steering vehicle capable of traversing rough terrains and on designing a mine detector. The vehicle and detector have been successfully constructed and are under test and evaluation.

PUBLICATION:

Kanayama, Y., Kaminer, I., Yun, X., Maruyama, X., and Ludlow, N., "An Integrated Ground and Aerial Robot System for UXO/Mine Detection," Proceedings of Symposium on Technology and the Mine Problem, Monterey, CA, 18-22 November 1996.

THESIS DIRECTED:

Goodnight, C., "Design and Evaluation of Mine and UXO Detectors for Autonomous Mobile Robots, Master's Thesis, Naval Postgraduate School, September 1996.

DoD KEY TECHNOLOGY AREAS: Sensors, Ground Vehicles, Other (UXO/Mine Detection)

KEYWORDS: Mine, UXO, robotic system, detection

DEVELOPMENT OF AN INFRARED PRESENCE SENSOR
Xiaoping Yun, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Office of Naval Research

OBJECTIVE: The objective is to develop an infrared presence sensor for robotic surveillance applications.

SUMMARY: Infrared sensors have been commercially utilized to construct motion detectors that are widely used for home and office security purpose. Infrared sensors only detect the change of infrared (or heat source) in the field of view. If no change is detected, e.g., a person stands in front of the sensor without moving, the sensor does not generate any signals. Some effort has been made in the research community to develop a presence sensor that is able to detect the presence of human body. All existing methods attempt to accomplish this by moving an infrared sensor in order to produce a relative change between the sensor and the human body. We have developed a completely new presence sensor design. Instead of moving the sensor, we keep the sensor stationary and use a rotating or sliding device to repeatedly block and unblock the sensor input. As a result, if there is a stationary person in front of the sensor, it generates a constant stream of pulses. In the absence of a human body, the sensor produces zero output. A preliminary prototype of the presence sensor has been built. Initial tests demonstrate that the method is feasible.

DoD KEY TECHNOLOGY AREAS: Sensors

KEYWORDS: Infrared, motion detector, presence sensor

AN INTEGRATED INS/GPS SHALLOW-WATER AUV NAVIGATION SYSTEM
Xiaoping Yun, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Unfunded

OBJECTIVE: The objective of this project is to develop an integrated self-contained shallow-water navigation system for autonomous underwater vehicles.

SUMMARY: Many autonomous underwater missions require a high degree of navigation accuracy. The global position system (GPS) is capable of providing this accuracy, but is not available when a vehicle is submerged. The objective of this project is to demonstrate the feasibility of using a low-cost strapped-down inertial measurement unit (IMU) to navigate between GPS fixes. A prototype system called SANS was built and tested in the laboratory as well as in Monterey Bay. The test results indicated that navigation accuracy comparable to that of GPS is achievable by IMUs between GPS fixes.

PUBLICATION:

Bachmann, E.R., McGhee, R.B., Whalen, R.H., Steven, R., Walker, R.G., Clynch, J.R., Healey, A.J., and Yun, X., "Evaluation on an Integrated GPS/INS System for Shallow-Water AUV Navigation (SANS)," Proceedings of 1996 IEEE Symposium on Autonomous Underwater Vehicle Technology, 1996, Monterey, CA, pp. 268-275, 2-6 June 1966.

THESES DIRECTED:

Campbell, M.S., "Real-Time Sonar Classification for Autonomous Underwater Vehicles," Master's Thesis, Naval Postgraduate School, March 1996.

Walker, R.G., "Design and Evaluation of an Integrated, Self-Contained GPS/INS Shallow-Water AUV Navigation System (SANS)," Master's Thesis, Naval Postgraduate School, March 1996.

DoD KEY TECHNOLOGY AREAS: Surface/Under Surface Vehicles - Ships and Watercraft

KEYWORDS: IMU, GPS, navigation, autonomous underwater vehicle

SUPPORT OF THE NEAR SHORE TACTICAL RECONNAISSANCE (NSTR) PROGRAM
Lawrence J. Ziomek, Professor
Department of Electrical and Computer Engineering
Sponsor: Defense Advanced Research Projects Agency and Naval Postgraduate School

OBJECTIVE: To deliver the recursive ray acoustics (RRA) computer algorithm to the Applied Physics Laboratory-Johns Hopkins University (APL-JHU) in support of the Near Shore Tactical Reconnaissance (NSTR) Program. To be available for consultation to APL-JHU to ensure the successful running, testing, and evaluation of the RRA algorithm. Time permitting, to further investigate the use of two-dimensional orthogonal function expansions of noise corrupted and/or uncertain environmental data and incorporate into the existing shallow water pulse-propagation model, which is based on the RRA algorithm. Specifically, fit surfaces to two-dimensional ocean-bottom depth data, that is, bathymetry as a function of cross-range and down-range. Such ocean bottom surface fits allow for the prediction of out-of-plane ray propagation due to bottom bounces which can impact bearing estimation algorithms used for target localization. In addition, fit surfaces to two-dimensional speed-of-sound data, that is, sound speed as a function of depth and down-range.

SUMMARY: The recursive ray acoustics (RRA) computer algorithm was delivered to the Applied Physics Laboratory-Johns Hopkins University (APL-JHU) in support of the Near Shore Tactical Reconnaissance (NSTR) Program. The RRA algorithm was run at both NPS and APL-JHU for several identical test cases. The results obtained from running the program at both institutions were exactly the same. Further evaluation and testing of the RRA algorithm at APL-JHU revealed that higher-order one-dimensional orthogonal function expansions of depth-dependent sound-speed data are required in order to successfully fit complicated sound-speed profiles. As a result, work has begun on increasing the maximum order fit from 5th order to 13th order for both sound-speed and bathymetric data. In addition, the use of the modified Gram-Schmidt orthogonalization technique is being investigated in order to provide the higher order fits with superior numerical stability. If this approach is successful, it will form the basis for two-dimensional orthogonal function expansions of environmental data.

OTHER:

Ziomek, L.J., "Three-Dimensional Ray Acoustics", half-day tutorial at the Oceanic Engineering Society-Autonomous Underwater Vehicle (OES-AUV) 1996 Symposium, Monterey, CA, 2-6 June 1996.

Ziomek, L.J., Recursive Ray Acoustics (RRA), computer program, transferred to Mr. C. Allan Boyles, Principal Staff Physicist of the Applied Physics Laboratory of The Johns Hopkins University, Baltimore, MD, 23 September 1996.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation

KEYWORDS: Recursive Ray Acoustics (RRA) algorithm, two-dimensional orthogonal function expansions of environmental data, pulse (transient) propagation modeling, shallow water acoustics, target localization

MATHEMATICAL MODELING OF DOLPHIN BIOSONAR

Lawrence J. Ziomek, Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Postgraduate School

OBJECTIVE: Two major objectives: 1) Begin to analyze and mathematically model experimental data of individual broadband click pulses transmitted by Tursiops Truncatus. If an accurate mathematical model of a click pulse can be obtained, then both the standard and generalized auto-ambiguity functions of an individual click pulse and the entire click pulse train can be computed. The range and Doppler resolving capabilities of the transmit signal of a Tursiops Truncatus can be obtained from its ambiguity function, and 2) Begin to analyze and mathematically model experimental data of the frequency response of the receive aperture of a Tursiops Truncatus in order to derive an accurate mathematical model of the receive aperture and receive far-field beam pattern of Tursiops Truncatus.

SUMMARY: The current mathematical model used to represent an individual broadband click pulse transmitted by Tursiops Truncatus is an amplitude-modulated carrier with a Gaussian amplitude-modulating function and no time-varying angle-modulating function. This is the so-called Gabor function model. However, the amplitude spectrum of the Gabor function does not match well with typical measured amplitude spectra of individual click pulses. Preliminary mathematical analysis and computer simulation studies indicate that using a Rayleigh-envelope LFM (linear frequency modulated) pulse, for example, is a more accurate representation of an individual broadband click pulse (in both the time and frequency domains) than the Gabor function.

The current mathematical model used to represent the receive aperture of Tursiops Truncatus is a two-element array where each element is modeled as a rectangular piston and the interelement spacing is 12 cm. However, since the physiological distance (approximately 12 cm) between the receive (hearing) organs on a Tursiops Truncatus is greater than the wavelengths of interest (corresponding to the frequency range of 30-120 kHz), array theory predicts a "grating lobe" problem for the horizontal receive far-field beam pattern for the two-element array model. However, measured horizontal receive far-field beam patterns for Tursiops Truncatus do not show any grating lobes. Preliminary mathematical analysis and computer simulation studies indicate discrepancies between measured and theoretical horizontal and vertical receive far-field beam patterns. Obviously, a more accurate mathematical model and more accurate experimental data of the receive aperture are needed.

DoD KEY TECHNOLOGY AREAS: Biomedical, Other

KEYWORDS: Biosonar, dolphin, dolphin biosonar

PUBLICATIONS/PRESENTATIONS

JOURNAL PAPERS

Buchner, S., Campbell, A.B., Weatherford, T.R., Knudson, A., McDonald, P., McMorrow, D., Fischer, B., Metzger, S., and Schlogl, M., "Charge Collection in GaAs MESFET Circuits Using a High Energy Microbeam," IEEE Transactions on Nuclear Science, Vol. 43, No. 6, December 1996.

Butler, J.T., and Sasao, T., "Average Number of Nodes in Binary Decision Diagrams of Fibonacci Functions," The Fibonacci Quarterly, Vol. 34.5, pp. 413-422, November 1996.

Dueck, G.W., and Butler, J.T., "A Heat-Quench Algorithm for the Minimization of Multiple-Valued Programmable Logic Arrays," Computer and Electrical Engineering Journal, Vol. 22, No. 2, pp. 103-107, 1996.

Fargues, M.P., and Brown, D.W., "Hands-On Exposure to Signal Processing Concepts Using the SPC Toolbox," IEEE Transactions on Education, May 1996.

Gill, G.S., "Simultaneous Pulse Compression and Pulse Doppler Processing with Step Frequency Waveforms," IEE Electronic Letters, Vol. 32, No. 23, November 1996.

Hunsucker, R.D., Rose, R.B., Adler, R.W., and Lott, G.K., "Auroral-E Mode Oblique HF Propagation and Its Dependence on Auroral Oval Position," IEEE Transactions, AP-S, Vol. 44, No. 3, pp. 383-388, March 1996.

Jenn, D., and Flokas, V., "Inband Scattering from Arrays with Parallel Feed Networks," IEEE Transactions on Antennas and Propagation, Vol. 44, No. 2, February 1996.

McMorrow, D., Weatherford, T.R., Buchner, S., Knudsen, A.R., Melinger, J.S., Tran, L.H., and Campbell, A.B., "Single-Event Phenomena in GaAs Devices and Circuits," IEEE Transactions on Nuclear Science, Vol. 43, No. 2, April 1996.

Neta, B., and Knorr, J.B., "Running NEC4 on the Cray at NPS," Applied Computational Electromagnetics Society Newsletter, Vol. 11, No. 3, pp. 12-15, November 1996.

Pieper, R.J., "Real-Time Histogram Generation Using Active Optical Scanning," Optics and Laser Technology, Vol. 28, No. 3, pp. 171-178, 1996.

Pieper, R., Cooper, A., and Pelegris, G., "Passive Range Estimation Using Dual Baseline Triangulation," Optical Engineering, Vol. 35, pp. 685-692, 1996.

Pace, P.E., Leino, R.E., and Styer, D., "Use of the Symmetrical Number System in Resolving Single-Frequency Under-Sampling Aliases," IEEE Transactions on Signal Processing, to be published 1996.

Pace, P.E., Ying, S.J., Powers, J.P., and Pieper, R.J., "Integrated Optical Sigma-Delta Modulators," Optical Engineering, Vol. 35, pp. 1828-1836, July 1996.

Robertson, R.C., and Sheltry, J., "Multiple Tone Interference of Frequency-Hopped Non-Coherent MFSK Signals Transmitted over Ricean Fading Channels," IEEE Transactions on Communications, Vol. 44, pp. 867-875, 1996.

Sasao, T., and Butler, J.T., "On Bi-decompositions of Logic Functions," Information Processing Society of Japan Notes, Vol. 96, No. 121, pp. 9-16, 12 December 1996.

Sasao, T., and Butler, J.T., "Planar Decision Diagrams for Multiple-Valued Functions," Multiple-Valued Logic: An International Journal, Vol. 1, pp. 39-64, 1996.

Sarkar, N., Kumar, V., and Yun, X., "Velocity and Acceleration Analysis of Contact Between Three-Dimensional Rigid Bodies," Transactions of the ASME, Journal of Applied Mechanics, Vol. 63, No. 4, pp. 974-984, December 1996.

Studer, J.A., Ha, T.T., and Borchardt, R.L., "A Time Domain Analysis of Direct Detection Dense WDM Networks with OOK Modulation," Journal of Optical Communications, Vol. 17, No. 6, pp. 231-236, December 1996.

Weatherford, T.R., Marshall, P.W., Dale, C., McMorrow, D., Peczalski, A., Carts, M., and Twigg, M., "Soft Error Immune LT GaAs ICs," 1996 IEEE GaAs IC Symposium Technical Digest, November 1996.

Yamamoto, Y., and Yun, X., "Effect of the Dynamic Interaction on Coordinated Control of Mobile Manipulators," IEEE Transactions on Robotics and Automation, Vol. 12, No. 5, pp. 816-824, October 1996.

CONFERENCE PAPERS

Adler, R.W., and Hoffman, A., "Using Amateur Radio CEM Codes to Gain Insight into VHF Ground Plane Antenna Performance and to Mitigate 75 Meter MARS RFI at a Naval Receiving Site," Proceedings of the 12th Annual Review of Progress in Applied Computational Electromagnetics, Naval Postgraduate School, March 1996.

Bachmann, E.R., McGhee, R.B., Whalen, R.H., Steven, R., Walker, R.G., Clynch, J.R., Healey, A.J., and Yun, X., "Evaluation on an Integrated GPS/INS System for Shallow-Water AUV Navigation (SANS)," Proceedings of 1996 IEEE Symposium on Autonomous Underwater Vehicle Technology, 1996, Monterey, CA, pp. 268-275, 2-6 June 1996.

Butler, J.T., Nowlin, J.L., and Sasao, T., "Planarity in ROMDD's of Multiple-Valued Symmetric Functions," Proceedings of the 26th International Symposium on Multiple-Valued Logic, pp. 236-241, May 1996.

Cristi, R., Caccia, M., Veruggio, G., "Motion Estimation and Modeling of the Environment for Underwater Vehicles," Proceedings of IARP 1996, Toulon, France, April 1996.

Cristi, R., Caccia, M., Veruggio, G., "Sonar Environment Modeling and Motion Navigation in UUV Navigation," Proceedings of MMAR '96, Miedzyzdroje, Poland, September 1996.

Fargues, M.P., and Barsanti, R.J., "Wavelet-Based Denoising of Acoustic Transients," Proceedings of the 30th Asilomar Conference on Signals, Systems, and Computers, November 1996.

Fargues, M.P., and Lelakis, I., "Applications of the Two-Dimensional Cepstrum to Speaker Identification," Proceedings of Signal and Image Processing '96, SIP-96, November 1996.

Fargues, M.P., Scott, T., and Coutu, G., "Adaptive Octave Filter with Adaptive Magnitude and Phase," Proceedings of the 30th Asilomar Conference on Signals, Systems, and Computers, November 1996.

Gill, G.S., and Huang, J.C., "Analysis of Step Frequency Radar Using Ambiguity Function," Proceedings of the Radar Processing, Technology, and Applications Conference, SPIE, August 1996.

Ha, T.T., and Powers, J.P., "A Discrete-Time Model for Coded Dense WDM Networks Employing Fabry-Perot Filters," Proceedings of VACETS VTIC '96, George Mason University, Fairfax, VA, 1-3 July 1996.

Ha, T.T., and Powers, J.P., "Optical FDMA Networks: A Discrete-Time Approach," Proceedings of MILCOM '96, McLean, VA, 21-24 October 1996.

PUBLICATIONS/PRESENTATIONS

Hippenstiel, R., and Payal, Y., "Wavelet Based Transmitter Identification," Proceedings of the 4th International Symposium on Signal Processing and its Applications, ISSPA '96, Gold Coast, Australia, 25-30 August 1996.

Hutchins, R.G., and Dunham, D.T., "Evaluation of a Probabilistic Multi-Hypothesis Tracking Algorithm in Cluttered Environments," Proceedings of the 30th Asilomar Conference on Signals, Systems, and Computers, Pacific Grove, CA, November 1996.

Hutchins, R.G., "Neural Network Chaotic System Identification," Proceedings of the 30th Asilomar Conference on Signals, Systems, and Computers, Pacific Grove, CA, November 1996.

Hutchins, S.G., and Hutchins, R.G., "Decision Support for Enhancing Tactical Air Situation Awareness," Proceedings of the 1st Annual Symposium on Situation Awareness in the Tactical Air Environment, Patuxent River NAS, MD, 4-5 June 1996.

Kanayama, Y., Kaminer, I., Yun, X., Maruyama, X., and Ludlow, N., "An Integrated Ground and Aerial Robot System for UXO/Mine Detection," Proceedings of Symposium on Technology and the Mine Problem, Monterey, CA, 18-22 November 1996.

Khalil, N., and Hippenstiel, R., "Wavelet Transforms of Correlation Functions of Frequency Hopped Signals," Proceedings 30th Asilomar Conference on Signals, Circuits and Computers, Pacific Grove, CA, November 1996.

Knorr, J.B., and Jenn, D.C., "A Numerical and Experimental Investigation of a Semi-Loop Antenna on a Metal Box," Proceedings of the 12th Annual Review of Progress in Applied Computational Electromagnetics, Monterey, CA, pp. 832-839, 18-22 March 1996.

Knorr, J.B., "A Numerical and Experimental Investigation of a Shipboard DF Array," Proceedings of the 12th Annual Review of Progress in Applied Computational Electromagnetics," Monterey, CA, pp. 792-801, 18-22 March 1996.

Lee, C.H., "RF Link Power Control with Field Test Data," Proceedings of the 30th Asilomar Conference on Signals, Systems, and Computers, Pacific Grove, CA, November 1996.

Lee, C.H., and North, R., "Decentralized Power Management in RF Mesh Networks for Frequency Reuse," Proceedings of the 30th Asilomar Conference on Signals, Systems, and Computers, Pacific Grove, CA, November 1996.

Michael, S., "Programmable Sampled Data Filter with Low Sensitivity Implementation," Proceedings of the International Conference on Electronics, Rhodes, Greece, October 1996.

Moose, P.H., "The Communications Environment of 2010: Difficulties in Forecasting," Proceedings of the 2nd International Command and Control Research and Technology Symposium, Market Bosworth, Warwickshire, U.K., 22-24 September 1996.

Morgan, M.A., and Robertson, R.C., "Impulse Receiving Antenna Design and Measurement," Abstracts of URSI Radio Science Meeting, p. 215, July 1996.

Morgan, M.A., and Robertson, R.C., "Optimized TEM Horn Impulse Receiving Antenna," Abstracts of Ultra-Wideband, Short Pulse EM 3 Conference, p. 92, May 1996.

Pace, P.E., and Patterson, R., "Wideband Opto-Electronic 14-Bit SNS A/D Converter," presentation to the Space and Naval Warfare Systems Command, San Diego, CA, 7 March 1996.

Pace, P.E., Sharp, K.C., and Morris, W.M., "ASCM Simulator Correlation Processor Bandwidth Considerations in Evaluating Effectiveness of Electronic Attack ," Proceedings of the 41st Annual Joint Electronic Warfare Conference, Naval Postgraduate School, May 1996.

PUBLICATIONS/PRESENTATIONS

Pace, P.E., Ying, S.J., Pieper, R.J., and Powers, J.P., "Optical Sigma-Delta Modulators Using Fiber Lattice Structure," Proceedings of the 29th Asilomar Conference on Signals, Systems, and Computers, IEEE Press, pp. 103-107, 1996.

Pieper, R.J., "A Second Generation Visibility Based Model for Objective/Subjective FLIR MRTD," ERIM Proceedings for the 1996 IRIS Specialty Group on Passive Sensors, Paper E2, Vol. 2, pp. 81-96, Monterey, CA, 1996.

Robertson, R.C., Janaswamy, E., and Morgan, M.A., "Ultra-Wideband Impulse Propagation," Abstracts of Ultra-Wideband, Short Pulse EM 3 Conference, p. 260, 1996.

Sarkar, N., and Yun, X., "Design of a Continuous Controller for Contact Transition Task Based on Impulsive Constraint Analysis," Proceedings of 1996 IEEE International Conference on Robotics and Automation, Minneapolis, MN, pp. 2000-2005, April 1996.

Sasao, T., and Butler, J.T., "Method to Represent Multiple-Output Switching Functions by Using Multi-Valued Decision Diagrams," Proceedings of the 26th International Symposium on Multiple-Valued Logic, pp. 248-254, May 1996.

Sasao, T., and Butler, J.T., "On Bi-Decompositions of Logic Functions," Information Processing Society of Japan Notes, Vol. 96, No. 121, pp. 9-16, December 12 1996.

Schleher, D.C., and Pace, P.E., "Support Jamming Effectiveness: Comparison of Direct Digital Synthesis and RF Memory Exciter Techniques ," Proceedings of the 41st Annual Joint Electronic Warfare Conference, Monterey, CA, May 1996.

Theodoss, M.D., and Robertson, R.C., "Performance of the FFH/BFSK Self-Normalized Receiver with Convolutional Coding and Soft Decision Decoding over Ricean Fading Channels with Partial-Band Noise Interference," Proceedings of IEEE Military Communications Conference, Vol. 2, pp. 436-441, 1996.

Therrien, C.W., and Jenkins, W.K., "New Insights in the Analysis of Polynomial Adaptive Filters," Proceedings of IEEE DSP Workshop, Loen, Norway, September 1996.

Therrien, C.W., Krebs, W.K., Lobik, D., and Essock, E.A., "Is an Integrated DOG(SO) or Wavelet Transform the Best Method to Model Sensitivity Profiles Underlying Desensitization-Sensitization Data?" Proceedings of the Annual Meeting of Association for Research in Vision and Ophthalmology, Fort Lauderdale, FL, April 1996.

Therrien, C.W., Li, X., and Jenkins, W.K., "Algorithms for Improved Performance in Adaptive Polynomial Filters with Gaussian Input Signals," Proceedings of the 30th Asilomar Conference on Signals, Systems, and Computers, Pacific Grove, CA, November 1996.

Therrien, C.W., Pierce, D.D., Chiu, C.-S., and Miller, J.H., "Matched-Mode Localization Using Conventional and Cumulant-Based MUSIC Algorithms in a Real, Complex Shallow Water Environment," Journal of the Acoustical Society of America, Vol. 100, No. 2, Pt. 2, October 1966 (3rd Joint Meeting Acoustical Societies of America and Japan).

Watkins, B.E., North, R., and Tummala, M., "Model Based Neural Network Predistortion of Nonlinear Amplifiers," Proceedings on World Congress on Neural Networks, San Diego, CA, 15-20 September 1996.

Watkins, B.E., North, R., and Tummala, M., "Predistortion of Nonlinear Amplifiers Using Neural Networks," Proceedings on MILCOM-96, McLean, VA, pp. 316-320, 21-24 October 1996.

Weatherford, T.R., Marshall, P.W., Dale, C., McMorrow, D., Peczalski, A., Baier, S., Carts, M., and Twigg, M., "Soft Error Immune LT GaAs ICs," IEEE GaAs IC Symposium Technical Digest, 1996.

PUBLICATIONS/PRESENTATIONS

Yamamoto, Y., Eda, H., and Yun, X., "Coordinated Task Execution of a Human and a Mobile Manipulator," Proceedings of 1996 IEEE International Conference on Robotics and Automation, Minneapolis, MN, pp. 1006-1011, April 1996.

Yun, X., and Sarkar, N., "Dynamic Feedback Control of Vehicles with Two Steerable Wheels," Proceedings of 1996 IEEE International Conference on Robotics and Automation, Minneapolis, MN, pp. 3105-3110, April 1996.

CONFERENCE PRESENTATIONS

Adler, R.W., "Mitigation of Digital Motor-Controller Radio Interference," presented at the Workshop on Factors Affecting the Performance of Naval Receiving Sites, Vienna, VA, April 1996.

Adler, R.W., "Radio Interference from Fluorescent Lights using Energy-Efficient Electronic Ballasts," presented at the Workshop on Factors Affecting the Performance of Naval Receiving Sites, Vienna, VA, April 1996.

Adler, R.W., "The Use of Simple Electromagnetic Modeling Software to Mitigate Encroachment at Naval Receiving Sites," presented at the Workshop on Factors Affecting the Performance of Naval Receiving Sites, Vienna, VA, April 1996.

Adler, R.W., and Hoffman, "Using Amateur Radio CEM Codes to Gain Insight into VHF Ground Plane Antenna Performance and to Mitigate 75 Meter MARS RFI at a Naval Receiving Site," 12th Annual Review of Progress in Applied Computational Electromagnetics, Monterey, CA, March 1996.

Buchner, S., Campbell, A.B., Weatherford, T.R., Knudson, A., McDonald, P., McMorrow, D., Fischer, B., Metzger, S., and Schlogl, M., "Charge Collection in GaAs MESFET Circuits Using a High Energy Microbeam," 1996 IEEE Nuclear and Space Radiation Effects Conference, Palm Springs, CA, 9 July 1996.

Butler, J.T., Nowlin, J.L., and Sasao, T., "Planarity in ROMDDs of Multiple-Valued Symmetric Functions," 26th International Symposium on Multiple-Valued Logic, May 1996.

Fargues, M.P., and Barsanti, R.J., "Wavelet-Based Denoising of Acoustic Transients," 30th Asilomar Conference on Signals, Systems, and Computers, Pacific Grove, CA, November 1996.

Frazier, S., Parimuha, E., Tummala, M., Winnenberg, T.F., and Martin, C.E., "Waveform Bounding and Combination Techniques for Inductively Coupled Direct Drive Testing," HART Conference, June 1996.

Ha, T.T., and Powers, J.P., "Optical FDMA Networks: A Discrete-Time Approach," 1996 IEEE Military Communications Conference, McLean, VA, 22 October 1996.

Ha, T.T., and Powers, J.T., "A Discrete-Time Model for Coded Dense WDM Networks Employing Fabry-Perot Filters," presented at the VTIC, George Washington University, Washington DC, July 1996.

Hippenstiel, R., and Payal, Y., "Wavelet based Transmitter Identification," 4th International Symposium on Signal Processing and its Applications, ISSPA '96, Gold Coast, Australia, 25-30 August 1996.

Hutchins, R.G., and Dunham, D.T., "Evaluation of a Probabilistic Multi-Hypothesis Tracking Algorithm in Cluttered Environments," 30th Asilomar Conference on Signals, Systems, and Computers, Pacific Grove, CA, November 1996.

Hutchins, R.G., "Modeling and Simulation in Electronic Warfare," 3rd Modeling and Simulation Conference, sponsored by the Association of Old Crows, Mitre Corporation, McLean, VA, 7 March 1996.

PUBLICATIONS/PRESENTATIONS

Hutchins, R.G., "Neural Network Chaotic System Identification," 30th Asilomar Conference on Signals, Systems, and Computers, Pacific Grove, CA, November 1966.

Hutchins, S.G., and Hutchins, R.G., "Decision Support for Enhancing Tactical Air Situation Awareness," 1st Annual Symposium on Situation Awareness in the Tactical Air Environment, Patuxent River NAS, MD, 4-5 June 1996.

Janaswamy, R., Hitney, H.V., Barrios, A., and Anderson, K.D., "A Rough Surface Split-Step Parabolic Equation Method for Radiowave Propagation," presented at the National Radio Science Meeting, Boulder, CO, 9-13 January 1996.

Jenn, D., "Test Plan for a Shipboard Demonstration of the Need-to-Calibrate Indicator," SPAWAR PMW-163 Baseline Review, Washington DC, 28 February 1996.

Khalil, N., and Hippenstiel, R., "Wavelet Transforms of Correlation Functions of Frequency Hopped Signals," 30th Asilomar Conference on Signals, Circuits and Computers, Pacific Grove, CA, November 1996.

Knorr, J.B., and Jenn, D.C., "A Numerical and Experimental Investigation of a Semi-Loop Antenna on a Metal Box," 12th Annual Review of Progress in Applied Computational Electromagnetics, Monterey, CA, 18-22 March 1996.

Knorr, J.B., "A Numerical and Experimental Investigation of a Shipboard DF Array," 12th Annual Review of Progress in Applied Computational Electromagnetics," Monterey, CA, 18-22 March 1996.

Lee, C.H., "Decentralized Power Management in RF Mesh Networks for Frequency Reuse," 30th Asilomar Conference on Signals, Systems, and Computers, Pacific Grove, CA, November 1996.

Lee, C.H., "Decentralized Power Management in RF Mesh Networks for Frequency Reuse," Workshop on New Techniques for Radio Communications and Wireless Networks, NRaD, San Diego, CA, 10 September 1996.

Lee, C.H., "RF Link Power Control with Field Test Data," 30th Asilomar Conference on Signals, Systems, and Computers, Pacific Grove, CA, November 1996.

Michael, S., "Programmable Sampled Data Filter with Low Sensitivity Implementation," International Conference on Electronics, Rhodes, Greece, October 1996.

Moose, P.H., "CODFM Modem Design for the High Data Rate Wireless Communications," IEEE Signal Processing Society, San Diego, CA, 12 September 1996

Morgan, M.A., and Robertson, R.C., "Optimized TEM Horn Impulse Receiving Antenna," 3rd International Conference on Ultra-Wideband, Short-Pulsed Electromagnetics, Albuquerque, NM, 27-31 May 1996.

Pace, P.E., and Rowe, A., "A Proposed NRL P-3 Integrated GPS/INS Targeting Architecture for Captive-Carry Experiments," Tactical Electronic Warfare Division, Naval Research Laboratory, Washington DC, 18 April 1996.

Pace, P.E., and Zulaica, D., "The Automatic Extraction of Threat Simulator Critical Parameters Version 1.0 ," Navy Unique Threat Simulator Validation Working Group, Monterey, CA, 31 January 1996.

Pace, P.E., " Introduction to the Center for Joint Services Electronic Warfare and Tour of Facilities," presentation to the Navy's Simulator Validation Working Group, Monterey, CA, 31 January 1996.

Pace, P.E., "Center for Joint Services Electronic Warfare Overview and Research in Ships Self Defense," presentation to the JDL-TPEW C3 CM Subpanel, Monterey, CA, 6 February 1996.

Pace, P.E., "Command and Control Frequency Management and Communication Technologies for the Battlefield," presentation to the Swedish War College Workshop-96, Swedish War College, Stockholm, Sweden, 11 November 1996.

Pace, P.E., "Introduction to the Center for Joint Services Electronic Warfare and Tour of Facilities," NATO Defense Research Group AC243 Panel 9, 45G10, Electronic Support Measures 24th Meeting, 18 March 1996.

Pace, P.E., Sharp, K.C., and Morris, W.M., "ASCM Simulator Correlation Processor Bandwidth Considerations in Evaluating Effectiveness of Electronic Attack," 41st Annual Joint Electronic Warfare Conference, Monterey, CA, May 1996.

Pieper, R.J., "A Second Generation Visibility Based Model for Objective/Subjective FLIR MRTD," 1996 IRIS Specialty Group on Passive Sensors, Monterey, CA, 13 March 1996.

Powers, J.P., "Acoustical Imaging from the Perspective of the Acoustical Imaging Symposia," 3rd Joint Meeting of the Acoustical Society of America and the Acoustical Society of Japan, Honolulu, December 4 1996. (Presented by J.P. Powers) (Abstract published in the Journal of Acoustical Society of America, Vol. 100, No. 4, Part 2, p. 2794, October 1996.)

Robertson, R.C., Janaswamy, R., and Morgan, M.A., "Ultra-Wideband Impulse Propagation," 3rd International Conference on Ultra-Wideband, Short-Pulsed Electromagnetics, Albuquerque, NM, 27-31 May 1996.

Sasao, T., and Butler, J.T., "Method to Represent Multiple-Output Switching Functions by Using Multi-Valued Decision Diagrams," 26th International Symposium on Multiple-Valued Logic, May 1996.

Sasao, T., and Butler, J.T., "On Bi-Decompositions of Logic Functions," Information Processing Society of Japan, 12 December 1996.

Schleher, D.C., and Pace, P.E., "Support Jamming Effectiveness: Comparison of Direct Digital Synthesis and RF Memory Exciter Techniques," 41st Annual Joint Electronic Warfare Conference, Monterey, CA, May 1996.

Shehata, K.A., and Fouts, D.J., "Complementary Gallium Arsenide Low-Power High-Speed Dynamic Logic," Workshop on Complementary Heterostructure FET (CHFET) Technology, Albuquerque, NM, 18-19 November 1996.

Theodoss, M.D., and Robertson, R.C., "Performance of the FFH/BFSK Self-Normalized Receiver with Convolutional Coding and Soft Decision Decoding over Ricean Fading Channels with Partial-Band Noise Interference," IEEE Military Communications Conference, McLean, VA, 21-24 October 1996.

Therrien, C.W., "Optimal Filtering for Removing Noise in Passive Sonar Data," ONR Peer Review, Austin, TX, 24-26 September 1996.

Vlachos, K., and Janaswamy, R., "A Wide Angle Split-Step Parabolic Equation Scheme for Tropospheric Propagation Over Irregular Terrain," 1996 PIERS Symposium, Innsbruck, Austria.

Watkins, B.E., North, R., and Tummala, M., "Model Based Neural Network Predistortion of Nonlinear Amplifiers," World Congress on Neural Networks, San Diego, CA, 15-20 September 1996.

Watkins, B.E., North, R., and Tummala, M., "Predistortion of Nonlinear Amplifiers Using Neural Networks," MILCOM-96, McLean, VA, 21-24 October 1996.

Weatherford, T.R., Marshall, P.W., Dale, C., McMorrow, D., Peczalski, A., Baier, S., Carts, M., and Twigg, M., "Soft Error Immune LT GaAs ICs," 1996 IEEE GaAs IC Symposium, 6 November 1996.

PUBLICATIONS/PRESENTATIONS

Weatherford, T.R., Marshall, P.W., Dale, C., McMorrow, D., Peczalski, A., Baier, S., Carts, M., and Twigg, M., "Soft Error Results on Honeywell C-HIGFET ICs on LT GaAs Buffers," 1996 SEU Symposium, Los Angeles, CA, 17 April 1996.

Weatherford, T.R., Marshall, P.W., Dale, C., Peczalski, A., Baier, S., McMorrow, D., Dietrich, H., and Twigg, M., "Soft Error Results on Honeywell C-HIGFET ICs on LT GaAs Buffers," 1996 LT GaAs Workshop, Santa Barbara, CA, 7 March 1996.

Yun, X., "Dynamic Feedback Control of Vehicles with Two Steerable Wheels," 1996 IEEE International Conference on Robotics and Automation, Minneapolis, MN, April 1996.

CONTRIBUTION TO BOOKS

Powers, J.P., Baylosis, B., Gatchell, P., and Reid, W., "Experimental Comparison of Measured Ultrasound Pressure Fields with Theoretical Prediction," Acoustic Imaging, Vol. 22, P. Tortoli and L. Masotti, eds., Plenum Publishing, New York, pp. 51-56, 1996.

Powers, J.P., Reid, W., Upton, J., and Van de Veire, R., "A Comparison of the Transient Propagation Properties of Bessel and Gaussian Waves," Acoustic Imaging, Vol. 21, J.P. Jones, ed., pp. 31-38, Plenum Publishing, New York, 1996.

TECHNICAL REPORTS

Buck, N., et al., "RENEGADE Spacecraft Design ," AA Spacecraft Design Final Report, with Top Secret SCI Annex, June 1996.

Fargues, M.P., "Classification of Ocean Acoustic Data Using AR Modeling and Wavelet Transforms," Naval Postgraduate School Technical Report, NPS-EC-96-020, December 1996.

Fargues, M.P., and Barsanti, R.J., "Underwater Signal Classification and Denoising Using Wavelet-Based Techniques," Internal Report, NUWC, August 1996.

Fargues, M.P., Barsanti, R.J., and Bennett, R., "Classification of Ocean Acoustic Data Using AR Modeling and Wavelet Transforms," Naval Postgraduate School Technical Report, NPS-EC-97-001, December 1996.

Gill, G.S., and Soares, P., "Step Frequency High PRF Waveform Design," Naval Postgraduate Technical Report, NPS-EC-96-008, June 1996.

Jenn, D., "Automatic Meshing of CAD Ship Files for Use with Numerical Electromagnetics Codes," Naval Postgraduate School Technical Report, NPS-EC-96-012, July 1996.

Jenn, D., "Computer Simulation of a Near-Field Need-to-Calibrate Indicator for Shipboard HFDF Systems," Naval Postgraduate School Technical Report, NPS-EC-96-019, September 1996.

Jenn, D., "Shipboard Demonstration of the Near-Field Need-to-Calibrate Indicator," Naval Postgraduate School Technical Report, NPS-EC-96-017, September 1996.

Knorr, J.B., "Computer Simulation of the OUTBOARD Direction Finding System on the DD963 Spruance Class Destroyer," NPS Technical Report NPS-EC-96-016, Monterey, CA, October 1996.

Lunde, K., et al., "RENEGADE Payload Design ," EC4750, SIGINT Systems II Final Report, Top Secret SCI, June 1996.

Morgan, M.A., "Electromagnetic Radiation Source Imaging," Project Report No. 1, Office of Naval Research, Code 334, August 1996.

Morgan, M.A., "NRaD Time-Domain Measurement Range Low-Frequency Performance Enhancement," Design Report No. 1, NRaD, Code 851, August 1996.

Morgan, M.A., "Pulse Excitation of Wire-Grid Antennas," Project Report No. 1, Naval Research Laboratory, May 1996.

Pace, P.E., "14-Bit 5 MHz Digital Antenna : Electro-Optical Digitizer and Hardware Realization," Naval Postgraduate School Technical Report, NPS-EC-96-011, August 1996.

Pace, P.E., "P-3 Captive-Carry Correlation (P3C3)-CHARLIE: Description and EW Flight Test Results Against the SLQ-32," Naval Postgraduate School Technical Report, NPS-EC-96-007, April 1996.

Perry, R.M., and Adler, R.W., "Evaluating Usefulness and Suitability of Groundwave Propagation Prediction Programs," Naval Postgraduate School Technical Report, NPS-EC-96-004, February 1996.

Robertson, R.C., Morgan, M.A., and Janaswamy, R., "Ultra-Wideband Impulse Propagation," Naval Postgraduate School Technical Report, NPS-EC-96-002, March 1996.

Smith, R.W., and Adler, R.W., "Nighttime VHF Transequatorial Propagation," Naval Postgraduate School Technical Report , NPS-EC-009, June 1996.

Smith, R.W., Hunsucker, R.D., and Adler, R.W., "Nighttime VHF Propagation Across the Auroral Oval," Naval Postgraduate School Technical Report, NPS-EC-010, June 1996.

Tummala, M., and Jeong, S., "Wideband Signal Analysis for Electromagnetic Transient Waveforms," Naval Postgraduate School Technical Report, NPS-EC-96-013, September 1996.

Tummala, M., Glenn, I., and Midwood, S., "Multisensor Data Fusion for the Vessel Traffic System," Naval Postgraduate School Technical Report, NPS-EC-96-015, October 1996.

Tummala, M., Therrien, C.W., and Shields, M.K., "A New Look: Beartrap Post-Mission Analysis System Initial System Design," Naval Postgraduate School Technical Report, NPS-EC-96-014, October 1996.

Vincent, W.R., "SNEP Quick Look Report, NSGA, Hanza, Okinawa CDAA Site," NSG Technical Report, March 1996.

Vincent, W.R., "SNEP Team Quick-Look Report, NSGA, Kunia, HI, Regional Operational Site," SECRET, NSG Technical Report, February 1996.

Vincent, W.R., "SNEP Team Quick-Look Report, NSGD, Sabana Seca, PR, CDAA Site," NSG Technical Report, April 1996.

Vincent, W.R., "SNEP Team Technical Report at the Sabana Seca, PR CDAA Site," NSG Technical Report, December 1996.

Vincent, W.R., "SNEP Team Technical Report, NSGA, Kunia, HI, Regional Operational Site," SECRET, NSG Technical Report, December 1996.

Vincent, W.R., and Adler, R.W., "EMI Survey at RSOC, Ft. Gordon, GA," USA INSCOM Technical Report, November 1996.

Vincent, W.R., and Adler, R.W., "EMI Survey at RSOC, Kunia, HI", NSG Technical Report, July 1996.

Vincent, W.R., and Adler, R.W., "SNEP Team Quick-Look Report, NSGD, Rota, Spain, CDAA Site," NSG Technical Report, June 1996.

Vincent, W.R., and Adler, R.W., "SNEP Team Quick-Look Report, NSGD Wahiahwa, HI," NSG Technical Report, July 1996.

Vincent, W.R., and Adler, R.W., "SNEP Team Quick-Look Report, NSGD Guantanamo Bay, Cuba," NSG Technical Report, September 1996.

Vincent, W.R., and Adler, R.W., "SNEP Team Quick-Look Report, RSOC Kunia, HI," NSG Technical Report, July 1996.

Wadsworth, D.v.Z., "Antijam Communications Performance Model for Navy Link-4C," Naval Postgraduate School Technical Report, NPS-EC-97-002, December 1996.

Yu, C.-K., and Lee, H.-M., "Zero On-Axis Backscattering of an Anisotropically Coated Shell of Revolution," Naval Postgraduate School Technical Report, NPS-EC-96-005, May 1996.

OTHER

Fargues, J.P., "Underwater Signal Classification and Denoising Using Wavelet-Based Techniques," seminar given at NUWC-New London Detachment, August 1996.

Pace, P.E., "Information and Electronic Warfare Technology," short course notes for the Swedish War College, October 1996.

Pace, P.E., "AETSCP: Program for the Automatic Extraction of Simulator Threat Critical Parameters Version 1.2," developed for the U.S. Navy Unique Simulator Validation Working Group (MATLAB software program).

Pace, P.E., and Styer, D., "High-Resolution Encoding Process with Robust Gray Code Properties for Folding ADCs, NC77837, Patent application filed June 19 1996.

Robertson, R.C., "Digital Spread Spectrum Communications Systems," notebook developed for short course at NSWC-DD, November 20-22 1996.

Robertson, R.C., Morgan, M.A., and Janaswamy, R., "Ultra-Wideband Impulse Propagation Version 1.0," MATLAB program developed for U.S. Army CECOM.

Therrien, C.W., "Optimal Nonlinear Systems and Higher-Order Statistics," IEEE Distinguished Lecturer Visit, Northern California Chapter of the IEEE Signal Processing Society, Santa Clara, CA, December 1996.

Therrien, C.W., "Higher-Dimensional Linear Prediction and Signal Modeling," Distinguished Lecturer Visit, France Chapter of the IEEE Signal Processing Society, Paris, France, October 1996.

Therrien, C.W., "Digital Sound Modeling and Synthesis," IEEE Distinguished Lecturer Visit, Spain Chapter of the IEEE Signal Processing Society, Madrid, Spain, October 1996.

PUBLICATIONS/PRESENTATIONS

Therrien, C.W., "Digital Sound Modeling and Synthesis," IEEE Distinguished Lecturer Visit, Turkey Chapter of the IEEE Signal Processing Society, Istanbul, Turkey October 1996.

Therrien, C.W., "Optimal Filtering for Removing Noise in Passive Sonar Data," ONR Peer Review, Austin, TX, September 24-26 1996.

Therrien, C.W., "Digital Sound Modeling and Synthesis," IEEE Distinguished Lecturer Visit, Utah Chapter of the IEEE Signal Processing Society, Salt Lake City, UT, May 1996.

Therrien, C.W., "Statistical Signal Processing," half-day tutorial, AUV Workshop, IEEE Oceanic Engineering Society, Monterey, CA, June 1996.

Vincent, W.R., and Munsch, G., "SNEP Power-Line Noise Mitigation Handbook," 3rd ed., COMMNAVSECGRU N-44, March 1996.

Ziomek, L.J., "Recursive Ray Acoustics (RRA)," computer program, transferred to Mr. C. Allan Boyles, Principal Staff Physicist of the Applied Physics Laboratory of The Johns Hopkins University on September 23 1996.

IDENTIFICATION OF PUSH-TO-TALK TRANSMITTERS
USING WAVELETS AND SPECTRAL CORRELATION

Abdulla Mufarrah Abdulla-Captain, Bahrain Army
B.S., Electrical Engineering, Northrop University, 1987
Master of Science in Electrical Engineering-September 1966
Advisors: Ralph Hippenstiel, Department of Electrical and Computer Engineering
Monique P. Fargues, Department of Electrical and Computer Engineering

The purpose of this thesis is to find an automated way to identify push-to-talk transmitters using a wavelet or a spectral correlation based approach. In the Wavelet approach, a distance algorithm is applied to the wavelet scales of the signal and the template. One signal from each transmitter signal set is taken as a template. The distance algorithm computes the distance between the local extrema of the wavelet coefficients of the template and the signal. Results show that the Wavelet Transform (WT) distance algorithm is able to classify the four signal sets accurately. Good identification results are achieved even at low signal-to-noise ratios. In the spectral correlation approach an averaged template for each signal set is used. The spectral coefficients for templates and signals are computed by extracting the magnitude squared of the Fast Fourier Transform (FFT) of the data. This method performs better for most signals than the wavelet method because it can identify at lower signal to noise levels than the wavelet method does.

IN-SITU MEASUREMENT OF TOTAL DOSE RADIATION EFFECTS ON PARALLEL PLATE MOS
CAPACITORS USING THE NPS LINEAR ACCELERATOR

Stuart M. Abrahamson-Lieutenant, United States Navy
B.S., Northwestern University, 1987
Master of Science in Electrical Engineering-December 1995
Master of Science in Astronautical Engineering-December 1995
Advisors: Sherif Michael, Department of Electrical and Computer Engineering
Oscar Biblarz, Department of Aeronautics and Astronautics

The study of radiation effects to electronics circuits has been ongoing almost as long as there have been satellites and spacecraft in space. The response to radiation over the planned life of the space system is of great concern to system designers. Operational amplifiers are one of the most basic elements in all electronic systems. This research examines radiation effects of part of a Metal Oxide Semiconductor (MOS) operational amplifier and is applicable to Complimentary MOS (CMOS) technology as well. More specifically, it is pertinent to MOS capacitors used to internally compensate op amps. First a review of semiconductor theory is presented followed by a discussion of damage mechanisms to MOS capacitors and a brief look at operational amplifier fundamentals. MOS capacitors, constructed by previous research efforts using the MOSIS technique, were selected as the internally compensating elements for simple low pass filters. Using the Naval Postgraduate School linear accelerator, these capacitors were irradiated with pulsed electrons possessing energies of up to 26 MeV for varying times. In-situ measurements were taken to immediately determine the capacitance value via the measured filter break frequency as a function of fluence. Separate irradiation runs were performed on three MOSIS capacitors and were terminated upon filter failure. This research concludes with a hypothesis of the filter failure mechanism and suggested areas for expansion of continuing research efforts. This is believed to be the first time such an experiment has been performed.

TROPOSPHERIC EFFECTS ON UHF RADIO WAVE PROPAGATION AT LOW ELEVATION ANGLES

Chad Francis Acey-Lieutenant, United States Navy
B.S., United States Naval Academy, 1989
Master of Science in Applied Physics-September 1996
Advisor: David D. Cleary, Department of Physics
Second Reader: Gus K. Lott, Department of Electrical and Computer Engineering

The effects of low elevation angles on radio wave propagation are determined, specifically in application to geolocation. Currently, data received at low elevation angles, generally those angles less than about 10°, are of little use due to the impact of the troposphere, obstacle shielding, multipath, and other issues that are not completely resolved. An experiment was conducted from 23 October to 03 November 1995 to study the practicality of using low elevation angle data for precise geolocation. The objectives were to first define tropospheric and other low elevation angle effects on ultra high frequency (UHF) geolocation by means of an experiment and analysis. The second objective was to develop compensation techniques. This analysis establishes a minimum value of 1.6° for a usable elevation angle. This analysis also shows the error from tropospheric effects, quantified in the miss distance, experienced at low elevation angles. Comparisons with geolocation cases clarifies the extent of the remaining problem at low elevation angles. Use of the Hopfield tropospheric model is shown to be effective in most instances.

LINE AND CIRCLE FORMATION OF DISTRIBUTED AUTONOMOUS MOBILE ROBOTS WITH LIMITED SENSOR RANGE

Okay Albayrak-Lieutenant Junior Grade, Turkish Navy
B.S., Turkish Naval Academy, 1990
Master of Science in Electrical Engineering-June 1996
Advisor: Xiaoping Yun, Department of Electrical and Computer Engineering
Second Reader: Robert G. Hutchins, Department of Electrical and Computer Engineering

In the literature, formation problems for idealized distributed autonomous mobile robots were studied. Idealized robots are represented by a dimensionless point, are able to instantaneously move in any direction and are equipped with perfect range sensors. In this thesis, line and circle formation problems of distributed mobile robots that are subjected to physical constraints are addressed. It is assumed that mobile robots that are subjected to physical constraints are addressed. It is assumed that mobile robots have physical dimensions, and their motions are governed by physical laws. They are equipped with sonar and infrared sensors in which sensor ranges are limited. A new line algorithm based on least-square line fitting, a new circle algorithm, and a merge algorithm are presented. All the algorithms are developed with consideration of physical robots and realistic sensors, and are validated through extensive simulations. Formation problems for mobile robots with limited visibility are also studied. In this case, robots are assumed to be randomly distributed in a large rectangular field such that one robot may not see other robots. An algorithm is developed that makes each robot converge to the center of the field before executing a line or circle algorithm.

GEOMETRIC FORMATION WITH UNIFORM DISTRIBUTION AND MOVEMENT IN FORMATION OF DISTRIBUTED MOBILE ROBOTS

Gokhan Alptekin-Lieutenant Junior Grade, Turkish Navy
B.S., Turkish Naval Academy, 1990
Master of Science in Electrical Engineering-June 1996
Advisor: Xiaoping Yun, Department of Electrical and Computer Engineering
Second Reader: Murali Tummala, Department of Electrical and Computer Engineering

The formation problem of distributed mobile robots was studied in the literature for idealized robots. Idealized robots are able to instantaneously move in any direction, and are equipped with perfect range sensors. In this study, the formation problem of distributed mobile robots that are subject to physical constraints is addressed. Mobile robots considered in this study have physical dimensions and their motions are governed by physical laws. They are equipped

with sonar and infrared range sensors. The formation of lines and circles by using the potential field method is investigated in detail. It is demonstrated that line and circle algorithms developed for idealized robots do not work well for physical robots. New line and circle algorithms, with consideration of physical robots and sensors, are presented and validated through extensive simulations. Movement in formation of a small group of physical mobile robots is also studied. An algorithm is developed using the potential field method that makes robots move through a work space filled with many obstacles while maintaining the formation.

DEVELOPMENT OF A NEW PREDICTION ALGORITHM AND A SIMULATOR FOR THE PREDICTIVE READ CACHE (PRC)

F. Nadir Altmisdort-Lieutenant Junior Grade, Turkish Navy
B.S., Turkish Naval Academy, 1990
Master of Science in Electrical Engineering-September 1996
Advisor: Douglas J. Fouts, Department of Electrical and Computer Engineering
Second Reader: Frederick W. Terman, Department of Electrical and Computer Engineering

Efforts to bridge the cycle-time gap between high-end microprocessors and low-speed main memories have led to a hierarchical approach in memory subsystem design. The predictive read cache (PRC) has been developed as an alternative way to overcome the speed discrepancy without incurring the hardware cost of a second-level cache. Although the PRC can provide an improvement over a memory hierarchy using only a first-level cache, previous studies have shown that its performance is degraded due to the poor locality of reference caused by program branches, subroutine calls, and context switches.

This thesis develops a new prediction algorithm that allows the PRC to track the miss patterns of the first-level cache, even with programs exhibiting poor locality. It presents PRC design alternatives and hardware cost estimates for the implementation of the new algorithm. The architectural support needed from the underlying microprocessor is also discussed.

The second part of the thesis involves the development of a memory hierarchy simulator and an address-trace conversion program to perform trace-driven simulations of the PRC. Using address traces captured from a SPARC-based computer system, the simulations show that the new prediction algorithm provides a significant improvement in the PRC performance. This makes the PRC ideal for embedded systems in space-based, weapons-based and portable/mobile computing applications.

DESIGN OF A UNIVERSAL TEST PLATFORM FOR RADIATION TESTING OF DIGITAL COMPONENTS

Duane E. Amsler, Jr.-Captain, United States Army
B.A., Clarkson University, Potsdam N.Y., 1986
Master of Science in Electrical Engineering-September 1996
Advisor: Douglas J. Fouts, Department of Electrical and Computer Engineering
Second Reader: Todd R. Weatherford, Department of Electrical and Computer Engineering

In this research, programmable, microcontroller-based test hardware was designed, constructed, debugged, and programmed. The wire-wrapped board will be used to test two custom static random access memory (SRAM) chips, as well as other custom chips designed at the Naval Postgraduate School. Components for the test hardware were selected to allow prototyping with standard parts that can later be replaced with radiation hardened parts as budgets permit. Control of the test hardware is via a RS-232 serial interface, which allows remote control programming and monitoring of the test hardware and device being tested.

A PIPELINED VECTOR PROCESSOR AND MEMORY ARCHITECTURE FOR CYCLO-STATIONARY PROCESSING

Raymond F. Bernstein, Jr.-Civilian
B.S., Texas Tech University, August 1977
M.S., Naval Postgraduate School, December 1982
Doctor of Philosophy in Electrical and Computer Engineering-December 1995
Advisor: Herschel H. Loomis, Jr., Department of Electrical and Computer Engineering

This work describes a scaleable, high performance, pipelined, vector processor architecture. Special emphasis is placed on performing fast Fourier transforms with mixed-radix butterfly operations. The initial motivation for the architecture was the computation of cyclostationary algorithms. However, the resulting architecture is capable of general purpose vector processing as well. A major factor affecting the performance of the architecture is the memory system design. The use of pipelining techniques, coupled with vector processing, places a substantial burden on the memory system performance. The memory design is based on an interleaved memory philosophy with a buffering technique referred to as split transaction memory (STM). A crucial aspect of the memory design is the memory decoding scheme. A design methodology is described for the specification of permutation matrices that yield near optimal performance for the memory system. Another important aspect of this work is the development of a software based simulator that allows a STM to be specified. The simulator, operating at the register transfer level, emulates the processing of an address stream by STM and records the events for post-processing. The STM simulator was used to evaluate three types of vector processing address patterns: constant stride, constant geometry radix-r butterfly, and digit reversed. A random address pattern was also analyzed in the context of general-purpose computing. STM simulation verified the near optimal performance of the STM.

GALLIUM ARSENIDE DRAM MEMORY CELL DESIGN AND EVALUATION OF TEST METHODS

Peter Allen Andreasen-Commander, United States Navy
B.S., United States Naval Academy, 1980
Master of Science in Electrical Engineering-December 1995
Advisor: D. Fouts, Department of Electrical and Computer Engineering

This thesis proposes a new Gallium Arsenide (GaAs) Dynamic Random Access memory (DRAM) storage cell design based on an n-type, depletion mode diode and evaluates an Emitter Coupled Logic (ECL) based test platform. The depletion mode diode storage cell exhibits improved charge storage and maintenance characteristics when compared with a previously designed capacitor-based storage cell. Power requirements of the diode-based cell are marginally increased. The modularity of the new diode-based design produces impressive improvements in Very Large Scale Integration (VLSI) layout. The smaller design promises a higher degree of memory cell integration for future GaAs DRAM applications. The ECL test platform provides DATA, READ, WRITE, REFRESH and CLOCK signals as well as power and ground requirements for a GaAs DRAM chip in a 132-pin package. All testbench systems are tested and prove functional but CLOCK and REFRESH signal integrity suffer from noise and connector losses above 10 MHz. Ultimately, the design fails as a test platform for the existing GaAs DRAM due to pin-out incompatibility. Recommendations for future test platforms are discussed along with suggestions for incorporation of the diode-based memory cell in new DRAM designs.

ANALYSIS OF DIGITAL CELLULAR STANDARDS

Rachel L. Pruitt-Billingsley-Lieutenant, United States Navy
B.S., Prairie View A&M University, 1987
Master of Science in Systems Technology-June 1996
Advisors: Dan C. Boger, Command, Control, and Communications Academic Group
Vicente Garcia, Department of Electrical and Computer Engineering

Cellular communications has become one of the fastest growing segments in the telecommunications industry. The demand for cellular services has risen beyond all expectations. With the current growth of the analog cellular network, a strain has been put on the existing system and available spectrum. Cellular providers have been forced to use the existing bandwidth more efficiently by converting to digital technology. Four major digital cellular techniques are competing for marketplace dominance and each has the ability to expand the capacity of the cellular networks. The four systems are Global System for Mobile Communications (GSM), the Pan-European standard that utilizes FDMA/TDMA, using 25 MHz bandwidth channels, and operates in the radio frequency bands of 890-915 MHz for the uplink and 935-960 in the downlink; Digital Advanced Mobile Phone System (D-AMPS), the North American Digital Standard which is backwards compatible with the existing AMPS system; IS-95 manufactured by Qualcomm Inc. which utilizes the newest of the technologies CDMA, and finally Personal Digital Cellular (PDC), Japan's alternative which also uses TDMA technology. It is uncertain which system will become the standard, but it is certain that the ability to get to the marketplace, dominate it, and secure a stronghold in the market will be the successful standard.

POWER RECOVERY OF RADIATION DAMAGED MOCVD GROWN INDIUM PHOSPHIDE ON SILICON SOLAR CELLS THROUGH ARGON-ION LASER ANNEALING

Lynn L. Boyer IV-Lieutenant, United States Navy
B.E., Vanderbilt University, 1989
Master of Science in Electrical Engineering-June 1996
Advisor: Sherif Michael, Department of Electrical and Computer Engineering
Second Reader: Ron J. Pieper, Department of Electrical and Computer Engineering

This thesis reports the results of a laser annealing technique used to remove defect sites from radiation damaged indium phosphide on silicon MOCVD grown solar cells. This involves the illumination of damaged solar cells with a continuous wave laser to produce a large forward-biased current. The InP/Si cells were irradiated with 1 MeV electrons to a given fluence, and tested for degradation. Light from an argon laser was used to illuminate four cells with an irradiance of 2.5 W/cm², producing a current density 3 to 5 times larger than AM0 conditions. Cells were annealed at 19°C with the laser and at 25°C under AM0 conditions. Annealing under laser illumination of n/p-type cells resulted in recovery of 48%. P/n type cells lost 4 to 12% of the assumed degradation. Annealing under AM0 conditions resulted in power recovery of 70% in n/p type cells. P/n-type cells recovered approximately 16% of lost power recovery of 70% in n/p type cells. P/n-type cells recovered approximately 16% of lost power. Results indicate that significant power recovery results from the annealing of defects within n/p type InP/Si solar cells.

IMPLEMENTING A LAN THAT INTERFACES WITH THE DMS AND USES MISSI

Lawrence Jay Brachfeld-Lieutenant, United States Navy
B.S., Rensselaer Polytechnic Institute, 1988
Master of Science in Information Technology Management-March 1996
Advisors: Rex Buddenberg, Department of Systems Management
Gus Lott, Department of Electrical and Computer Engineering

The Defense Message System (DMS) is being implemented throughout the Department of Defense and will replace AUTODIN for individual and organization messages by the year 2000. The Naval Security Group Detachment, Monterey and any other command that sends or receives organizational or individual messages must be ready to implement DMS on their Local Area Network. This thesis fully describes the Defense Messaging System standards and components and

details what needs to be implemented in a Local Area Network in order to be prepared for the initial operating capability of the DMS, scheduled for July, 1996.

REAL-TIME SONAR CLASSIFICATION FOR AUTONOMOUS UNDERWATER VEHICLES
Michael Scott Campbell-Lieutenant, United States Navy
B.S.E.E., Ohio Northern University, 1989
Master of Science in Electrical Engineering-March 1996
Master of Science in Computer Science-March 1996
Advisors: Don Brutzman, Undersea Warfare Academic Group
Xiaoping Yun, Department of Electrical and Computer Engineering

The Naval Postgraduate School autonomous underwater vehicle (AUV) Phoenix did not have any sonar classification capabilities and only a basic collision avoidance system. The Phoenix also did not have the capability of dynamically representing its environment for path planning purposes.

This thesis creates a sonar module that handles real-time object classification and enables collision avoidance at the Tactical level. The sonar module developed communicates directly with the available sonar and preprocesses raw data to a range/bearing data pair. The module then processes the range/bearing data using parametric regression to form line segments. A polyhedron-building algorithm combines line segments to form objects and classifies them based on their attributes. When the Phoenix is transiting, the classifying algorithm detects collision threats and initiates collision avoidance procedures.

The result of this thesis is a fully implemented sonar module on the Phoenix. This module was tested in a virtual world, test tank and in the first ever sea-water testing of the Phoenix. The sonar module has demonstrated real-time sonar classification, run-time collision avoidance and the ability to dynamically update the representation of the unknown environment. The sonar module is a forked process written in the "C" language, functioning at the Tactical level. Source code and output from an actual Phoenix mission displaying the object classification of the sonar module are included.

GEOLOCATION WORKBENCH
Robert E. Campbell-Lieutenant, United States Navy
B.S., Troy State University, 1985
Master of Science in Computer Science-December 1995
Advisors: Herschel H. Loomis, Jr., Department of Electrical and Computer Engineering
Timothy J. Shimeall, Department of Computer Science

This thesis defines software requirements for a geolocation workbench software environment. A geolocation workbench is a tool that studies the algorithms that provide the location of an active transmitter using techniques such as Time Difference of Arrival (TDOA) or Frequency Difference of Arrival (FDOA). The study would involve efficiency of calculation, accuracy of results and sensitivity to error.

The approach taken was the development of a rapid prototype of the Geolocation Workbench. The prototype implements the Geolocation Workbench system user interface and is evaluated by the customer, Professor Loomis of the Department of Electrical and Computer Engineering, Naval Postgraduate School, to refine the requirements. The requirements call for measuring TDOA, FDOA and emitter motion errors.

The results were as follows: After three prototype demonstrations and six one hour meetings a total of 50 screen panels were created with the desired functionality described in each panel. The functions included having the ability to enter text, display graphics, make file selections and edit data.

A GLOBAL BROADCAST SERVICE FOR THE USER ON THE MOVE

Robert S. Carlisle-Lieutenant, United States Navy
B.S., United States Naval Academy, 1988
Master of Science in Systems Technology (Space Systems Operations)-June 1996
Advisor: Paul Moose, Department of Electrical and Computer Engineering
Second Reader: Donald v. Z. Wadsworth, Department of Electrical and Computer Engineering

In an effort to increase the amount of bandwidth available to ships and other disadvantaged users, the Department of Defense has initiated the Global Broadcast Service. This service uses commercial Direct Broadcast Satellite technology to broadcast video and data at high data rates to small and affordable terminals. The evolution of this technology, its commercial applications, and the Department of Defense's strategy for implementation of the Global Broadcast Service are summarized to illustrate the feasibility of providing this service to an on the move user. A satellite downlink budget from an actual demonstration involving the broadcast of Global Broadcast Service products to moving platforms is analyzed to highlight the limitations and further development required to provide this service to a user on the move. Several examples are given of how such a service to an on the move user could benefit military operations. Finally, several recommendations are provided concerning the future use and development of a Global Broadcast Service for the user on the move.

DESIGN AND IMPLEMENTATION OF A WORLD WIDE WEB CONFERENCE INFORMATION SYSTEM

Michael D. Chalfant, Jr.-Lieutenant, United States Navy
B.S., Tulane University, 1988
Master of Science in Information Technology Management-September 1996
and
Kevin M. Coats-Lieutenant, United States Navy
B.S., Mathematics, University of Texas, 1986
Master of Science in Information Technology Management-September 1996
Advisors: Monique P. Fargues, Department of Electrical and Computer Engineering
Kishore Sengupta, Department of Systems Management

The Asilomar Conference on Signals, Systems and Computers is a technical conference dealing in signal and image processing, communications, sensor systems, and computer hardware and software. Sponsored by the Naval Postgraduate School and San Jose State University, in cooperation with the IEEE Signal Processing Society, the conference is held annually at the Asilomar Conference Facility in Pacific Grove, California. Although the Asilomar Conference is oriented toward computers and new technology, it has yet to exploit the full capabilities of the Internet.

The purpose of this thesis is to: a) Analyze the processes involved in the Asilomar Conference on Signals, Systems, and Computers, b) Improve the article submission and review process, c) Outline a target information system, and d) Implement a portion of the target system.

Two major portions of the target system are implemented using an IBM compatible PC: 1) the ability for authors to submit abstracts and summaries via the Internet, and 2) to allow conference administrators to manage the database via the Internet. Dynamic World Wide Web pages are created using Borland Delphi as the programming base, O'Rielly's WebSite as the web server, and two Common Gateway Interface elements for Delphi recently developed by Ann Lynnworth of HREF Tools Corp. The portions implemented lay the foundation for a system that could revolutionize the way conferences are conducted by unleashing the power of the Internet.

ANNEALING OF DEFECT SITES IN RADIATION DAMAGED INDIUM PHOSPHIDE SOLAR CELLS THROUGH LASER ILLUMINATION

Charles Thomas Chase-Lieutenant, United States Navy
B.S., Massachusetts Institute of Technology, June 1987
Master of Science in Astronautical Engineering-December 1995
Advisor: Sherif Michael, Department of Electrical and Computer Engineering

This thesis reports the results of a laser annealing technique used to remove defect sites from radiation damaged indium phosphide diffused junction solar cells. This involves the illumination of damaged solar cells with a continuous wave laser to produce a moderate heating and a large forward-biased current. The InP cells were irradiated with 27 MeV electrons to a given fluence, and tested for degradation. Light from an argon laser was used to illuminate each cell with an irradiance of 2.5 W/cm^2, producing a current density 7 to 10 times larger than under AM0 conditions. Cells were annealed at 48.5°C, 60°C, and 75°C for periods of 15 to 60 minutes, and cooled to 25°C for power recovery determination. Annealing at 48.5°C resulted in a recovery of 17 to 18% of the power lost due to irradiation, and annealing cells at 60°C produced a recovery of 43 to 48%. A single test of the technique at 75°C produced a net recovery of only 21% of the power lost. These results indicate that significant power recovery resulting from the annealing of defects within InP solar cells. Continuing research should involve the repeating of the test at 75°C, and irradiations with electrons or protons of energies expected in the space environment.

SPECIAL ABSTRACT MODELING AND SIMULATION OF A SEARCH RADAR RECEIVER

Chung-Yi Chen-Lieutenant Colonel, Republic of China Army
B.S., Chung-Cheng Institute of Technology, 1981
Master of Science in Systems Engineering-September 1996
Advisor: Hung-Mou Lee, Department of Electrical and Computer Engineering
Second Reader: D. C. Jenn, Department of Electrical and Computer Engineering

Evaluation of radar performance using an actual radar is extremely costly. Such a process usually provides only samples of data under limited and difficult-to-control scenarios. In contrast, computer simulation using a validated model of the radar system provides flexible and cost-effective means of testing various aspects of the system. This research represents an initial attempt on this goal: construct function-by-function validated models of radar systems for performance assessment on the computer and produce simulation software which can accept environment data and threat scenarios and drive the radar models. Several desirable aspects of radar operations have not been included in this work. Among them the multiple PRF capability and range-Doppler ambiguity resolution; ECCM features such as carrier frequency agility and sidelobe cancellation; clutter map for enhanced zero velocity target detection are the ones to be considered for implementation in the immediate future.

INTERMODULATION IN CHANNELIZED DIGITAL ESM RECEIVER

Ming-Jen Cheng-Major, Republic of China Air Force
B.S., University of Tulsa, 1991
Master of Science in Systems Engineering-September 1996
Advisor: D. C. Schleher, Information Warfare Academic Group
Second Reader: David C. Jenn, Department of Electrical and Computer Engineering

This thesis investigates intermodulation distortion generated by analog-to-digital converters (ADCs) in a channelized digital ESM receiver when processing multiple signals simultaneously. Spurious free dynamic range (SFDR) associated with this distortion is discussed. Two methods for increasing spurious free dynamic range are evaluated. First, by adding a small amount of Gaussian noise to the input of the receiver, the intermodulation distortion is found to be reduced significantly. Second, by using a narrow bandwidth sub-Nyquist sampling rate with high dynamic range ADCs it is possible to increase the spurious free dynamic range of the digital receiver. The first method is a simple approach

but the ability to increase the SFDR is limited. The second method is more effective but requires greater computation and complex receiver design.

PERFORMANCE ANALYSIS OF FFH/BPSK RECEIVERS WITH CONVOLUTIONAL CODING AND SOFT DECISION VITERBI DECODING OVER CHANNELS WITH PARTIAL-BAND NOISE INTERFERENCE

Emmanouil Christofis-Lieutenant, Hellenic Navy
B.S., Hellenic Naval Academy, 1988
Master of Science in Electrical Engineering-March 1996
Advisor: R. Clark Robertson, Department of Electrical and Computer Engineering

An analysis of the performance of a binary phase shift keying (BPSK) communication system employing fast frequency-hopped (FFH) spread spectrum modulation, under conditions of hostile partial-band noise interference, is performed in this thesis. The data are assumed to be encoded using convolutional coding and the receivers are assumed to use soft decision Viterbi decoding.

The receiver structures to be examined are the conventional FFH/BPSK receiver with diversity, the conventional FFH/BPSK receiver with diversity and the assumption of perfect side information, and the noise-normalized FFH/BPSK combining receiver with diversity. The FFH/BPSK noise-normalized receiver with diversity minimizes the effects of hostile partial-band noise interference and alleviates the effects of fading. The effect of inaccurate measurement of the noise power present in each hop is also examined, and it is found that noise measurement error does not significantly degrade receiver performance. For the conventional FFH/BPSK receiver with perfect side information, the effect of a Ricean fading channel is also examined.

A COMPARISON STUDY OF CDMA VERSUS TDMA/FDMA LEO SATELLITE SYSTEMS

Timothy M. Ciocco-Lieutenant, United States Navy
B.S., Boston College, 1988
Master of Science in Electrical Engineering-March 1996
Advisor: Paul H. Moose, Department of Electrical and Computer Engineering

In this thesis, two LEO satellite systems with different multiple access schemes are analyzed. The first system, GLOBALSTAR, uses CDMA. Equations are developed to calculate the maximum capacity of one satellite, of one satellite's user beam, and of the entire GLOBALSTAR system over CONUS. A detailed description of GLOBALSTAR's outrage probability, the probability that a call will be dropped from the system or blocked from connection with the system, is given and graphed against varying average call time and varying call arrival rate. The second system, IRIDIUM, uses TDMA/FDMA. Equations are similarly developed to calculate the maximum capacity of one satellite, of one satellite's user beam, and of the entire IRIDIUM system over CONUS. The probability of success or failure of an IRIDIUM subscriber obtaining a system channel is given by the Erlang Loss Formula and graphed against varying average call time and varying call arrival rate. Results show GLOBALSTAR provides five times the service capacity of IRIDIUM over CONUS and provides a better probability of obtaining a system channel for a call than will IRIDIUM.

OPTIMAL DIGITAL DETECTION OF ACOUSTIC SIGNALS IN COLORED NOISE

Martin Cloutier-Captain, Canadian Armed Forces
B. Eng., Royal Military College of Canada, 1986
Master of Science in Electrical Engineering-December 1995
Master of Science in Engineering Acoustics-December 1995
Advisors: Ralph Hippenstiel, Department of Electrical and Computer Engineering
Roberto Cristi, Department of Electrical and Computer Engineering

This thesis addresses optimal methods for the detection of acoustic signals corrupted by colored noise. In achieving this we provide a study of the characteristics of ambient noise in the ocean and the digital techniques which can be used in the process of detecting known acoustic signals which are corrupted by that noise. Various techniques are studied, in particular the use of matrix decomposition techniques applied to the correlation matrix or to a data matrix, and the matched filter for colored noise. Other methods such as the inverse filter, the differential operator, and the adaptive prediction-error filter will also be looked at for their whitening properties. The theoretical foundations of those techniques are presented as well as the application of each method to the problem. Simulations are conducted for each technique in order to provide quantified performance measurements supporting the use of each method.

ANALYSIS AND PERFORMANCE COMPARISON OF ADAPTIVE DIFFERENTIAL PULSE CODE MODULATION DATA COMPRESSION SYSTEMS

Michael V. Cooperwood-Lieutenant, United States Navy
B.S., University of South Carolina, 1986
Master of Science in Electrical Engineering-March 1996
Advisor: Monique P. Fargues, Department of Electrical and Computer Engineering

Advances in audio data compression are largely driven by the need to conserve transmission rate or bandwidth, while maintaining the ability to accurately reconstruct the signal at the receiver. This thesis examines data compression methods with an emphasis on techniques for the compression of audio data. An overview of data compression schemes is presented to provide the background for a performance comparison between selected versions of data compression systems featuring adaptive differential pulse code modulation (ADPCM) schemes. Two different types of data compression systems are investigated; IIR and FIR impulse implementations. A modification to the basic ADPCM system using a modular function is implemented. The modular operation results in a smaller size codebook and prevents data expansion when the source is not matched to the code. This modification is utilized for both types of ADPCM coders compared. To complete the compression system, Huffman coding is employed to encode and decode the compressed data to and from binary form.

DETECTION AND IDENTIFICATION OF CYCLOSTATIONARY SIGNALS

Evandro L. da Costa-Lieutenant Commander, Brazilian Navy
B.S., Instituto Militar de Engenharia, 1980
Master of Science in Electrical Engineering-March 1996
Master of Science in Engineering Acoustics-March 1996
Advisors: Ralph Hippenstiel, Engineering Acoustics Academic Committee
Roberto Cristi, Department of Electrical and Computer Engineering

Propeller noise can be modeled as an amplitude modulated (AM) signal. Cyclic Spectral Analysis has been used successfully to detect the presence of analog and digitally modulated signals in communication systems. It can also identify the type of modulation. Programs for Signal Processing based on compiled languages such as FORTRAN or C are not user friendly, and MATLAB based programs have become the *de facto* language and tools for signal processing engineers worldwide.

This thesis describes the implementation in MATLAB of two fast methods of computing the Spectral Correlation Density (SCD) Function estimate, the FFT Accumulation Method (FAM) and the Strip Spectral Correlation Algorithm

(SSCA), to perform Cyclic Analysis. Both methods are based on the Fast Fourier Transform (FFT) algorithm. The results are presented and areas of possible enhancement for propeller noise detection and identification are discussed.

THE INFLUENCE OF PHYSICAL SYSTEM PARAMETERS ON THE PERFORMANCE OF ADAPTIVE FILTERS FOR SYSTEM IDENTIFICATION OF MECHANICAL SYSTEMS
Michael R. Dargel-Lieutenant, United States Navy
B.S.M.E., Norwich University, 1990
Master of Science in Engineering Acoustics-September 1996
Advisors: Robert M. Keolian, Department of Physics
Roberto Cristi, Department of Electrical and Computer Engineering

Recursive and non-recursive least mean square adaptive filters were used to predict the output of various mechanical systems for a given input. The effects of quality factor (Q), dispersion and transmission time on adaptive filter performance were investigated. Optimal filter delay times and tap weight vector lengths were determined.

FORMAL SPECIFICATION, VERIFICATION, AND ANALYSIS OF THE RELIABLE MULTICAST TRANSPORT PROTOCOL
Jerry Bennett Dismuke-Lieutenant, United States Navy
B.S., United States Naval Academy, 1988
Master of Science in Electrical Engineering-December 1995
Advisors: G.M. Lundy, Department of Computer Science
Herschel Loomis, Department of Electrical and Computer Engineering

This thesis explores the feasibility and reliability of a Reliable Multicast Transport Protocol (RMTP) under development at AT&T Bell Laboratories. A formal specification and verification was conducted using the *systems of communicating machines* model to determine if the specification of the protocol is free from deadlocks, livelocks, and unspecified receptions. This model was programmed using the ADA programming language. An analysis was done using these programs as input to programs that perform reachability analysis on the model of the protocol. Results of the analysis indicate that the RMTP protocol is free from deadlocks and livelocks with a few exceptions. Suggestions are provided to improve the specification of the protocol. In addition to the research on the RMTP protocol, greater knowledge was acquired in the area of modeling communication channels and networks.

ATTACKING THE INFRASTRUCTURE: EXPLORING POTENTIAL USES OF OFFENSIVE INFORMATION WARFARE
Donald E. Elam-Lieutenant, United States Navy
B.S., United States Naval Academy, 1990
Master of Science in Systems Technology-June 1996
Advisors: Dan Boger, Command, Control, and Communications Academic Group
Vicente Garcia, Department of Electrical and Computer Engineering

The world has entered the Third Wave; it has entered the Information Age. One of the fundamentals of this paradigm shift is the fact that information is power. The side that controls information more effectively will be victorious. Thus, countries and militaries must change their mentality in order to survive. A new form of conflict, Information Warfare, has been born. This new discipline is large, dynamic, and complex.

The need exists for education among military officers and other concerned professionals throughout the country. This thesis helps to bridge the education gap. It presents a snapshot of Information Warfare today, exploring many different avenues and possibilities along the way. The first half of the document is focused on Information Warfare in general, and the second half deals specifically with the offensive side.

The purpose of this thesis is not to present an all-encompassing view of Offensive Information War or even of Information Warfare in general. The field of Information Warfare is too big for any one individual or organization to

fully comprehend all of its intricacies. Indeed, due to the dynamic nature of this discipline, chances are that some, or maybe even all, of the material contained herein will be obsolescent upon publication. The goal of the thesis is to present one view of Information Warfare, as seen through the eyes of many. The hope is that some benefit will be garnered by the reader, even if it only sparks an idea or helps to understand the importance of this growing warfare dimension.

COMINT ANALYSIS IN A LITTORAL ENVIRONMENT
Ricardo Rangee Ferreira-Lieutenant Commander, Brazilian Navy
B.S., Brazilian Naval Academy, 1984
Master of Science in Systems Engineering-September 1996
Advisor: Donald v. Z. Wadsworth, Department of Electrical and Computer Engineering
Second Reader: Kenneth Davidson, Department of Meteorology

This study consists of a performance evaluation of ship-mounted COMINT systems collecting against VHF/UHF data/voice signals in a littoral environment. The detection range for each combination of collector and emitter was determined with the aid of the AFIWC software program "Passive Detection (PD)". The atmosphere propagation effects and phenomena such as trapping and ducting were taken into account using the NCCOSC software program "Engineer's Refractive Effects Prediction System (EREPS)". The performance of COMINT systems against representative RF receiver and transmitter systems, including cellular and SATCOM systems in the UHF band, was evaluated and summarized in a matrix, as the end product of this work. The unclassified study was limited to the capability of the modeling programs, including the availability of the environmental data concerning the area as well as the characteristics of the equipment evaluated. Geolocation was not included.

DESIGN TRADEOFFS IN RADIATION HARDENED
ASICS FOR SPACE APPLICATIONS
Tyson James Gallander-Lieutenant, United States Navy
B.S., United States Naval Academy, 1990
Master of Science in Electrical Engineering-June 1996
Advisor: Douglas J. Fouts, Department of Electrical and Computer Engineering
Second Reader: Todd R. Weatherford, Department of Electrical and Computer Engineering
Third Reader: Steven S. Chang, Department of Defense

The availability of radiation hardened integrated circuits (ICs) is declining, yet the need for radiation hardened ICs is growing. This thesis explores techniques for radiation hardening ICs fabricated with commercial CMOS processes rather than using more expensive process hardening methods. A design environment based on the Boeing Defense and Space Group Aerospace Compiler is investigated for speed, accuracy, ease of use, and level of radiation hardness. A design and implementation of the Fireworks2 FIR filter is utilized to evaluate the area, speed, power consumption and radiation hardness trade-offs of using the described design environment.

INTEGRATION OF INTELLIGENCE RESOURCES INTO THE
AN/SRS-1 SIGNAL DETECTION AND DIRECTION FINDING SET
James Randall Garner-Lieutenant, United States Navy
B.S., United States Naval Academy, 1990
Master of Science in Systems Engineering-September 1996
Advisors: Herschel H. Loomis, Jr., Department of Electrical and Computer Engineering
Vicente Garcia, Department of Electrical and Computer Engineering

As the United States faces the next century of warfare in the information age, the importance of Signals Intelligence (SIGINT) will increase. For the United States Navy to maintain pace with the evolution of global technologies and its

impact on intelligence operations, the afloat cryptologist must play a larger role in the detection and exploitation of potential Signals of Interest (SOI).

This thesis examines the AN/SRS-1 Combat Direction Finding System (Combat DF) and how intelligence assets can be coupled to efficiently meet future operational demands of the joint warfighter. In addition, direction is given for future improvements in the Special Intelligence communications networks. Although potentially unobtainable in the foreseeable future, these ideas are intended to explore possibilities regarding our information interchange methods and associated hardware.

Through a review of the signal analysis capabilities of Combat DF, this thesis highlights specific signal analysis improvements immediately available through the use of existing signal processing tools such as MARTES. Using a signal analysis example, the immediate beneficial impact of including a Signal Analysis Workstation (SAW) to complement Combat DF will be clear to the reader. As a minimum, the obvious benefit of additional signal analysis capabilities should be clearly visible.

IMPLEMENTATION OF A DIGITAL COMMUNICATION SYSTEM USING QPSK MODULATION
Dilip B. Ghate-Lieutenant, United States Navy
B.S., Rensselaer Polytechnic Institute, 1988
Master of Science in Electrical Engineering-December 1995
Advisor: Murali Tummala, Department of Electrical and Computer Engineering

With the advances in high speed, programmable digital signal processing (DSP) chips, modern communications links are using a combination of DSP techniques and digital communications methods to realize faster, reconfigurable, and modular systems. This thesis details the software implementation of a modern digital communication system combining various DSP functions, channel Forward Error Correcting (FEC) algorithms, and digital modulation methods. The digital modulation schemes considered here include both baseband and Quadrature Phase Shift Keying (QPSK) techniques. The proposed communication system will serve as a practical tool useful for simulating the transmission of any digital data. The various modules of the system include source encoders/decoders, data compression functions, channel encoders/decoders, and modulators/demodulators. Implementation consists of coding the various link functions in C and integrating them as a complete system. The results show the viability of a QPSK modulated digital communications link and point the direction of future research towards software radio.

NEURAL PREDICTION OF MISSILE DYNAMICS DURING HARDWARE-IN-THE-LOOP CAPTIVE-CARRY EXPERIMENTS
Charles W. Gill-Lieutenant, United States Navy
B.S., United States Naval Academy, 1989
Master of Science in Aeronautical Engineering-September 1996
Advisor: Phillip E. Pace, Department of Electrical and Computer Engineering
Second Reader: Robert E. Ball, Department of Aeronautics and Astronautics

Systems using electronic attack (EA) are needed to defeat enemy active threat missiles. Many such systems exist, but difficulties arise when trying to measure their effectiveness. Two methods used are closed loop tests in an anechoic chamber and open loop tests conducted with a hardware-in-the-loop (HIL) threat simulator on board an aircraft. This thesis investigates the feasibility of using a particular class of neural networks (Levenburg-Marquardt) to predict the dynamics of an anti-ship cruise missile (ASCM) using only the seeker measured range-to-target and antenna azimuth and elevation angles. This technique accounts for seeker measured range and angles having a nonlinear relationship with the missile flight dynamics. Closed loop anechoic chamber simulations provide missile dynamics in an artificial environment while open loop captive-carry flight tests provide a true EA environment, but no dynamics. Closed loop and open loop results are combined to assess the effectiveness of the EA used by the Navy to defeat enemy missiles. The neural networks are trained using missile dynamics from closed loop simulations and are used to provide missile dynamics for open loop simulations. As an integral part of captive-carry signal processing tools, the prediction of the ASCM dynamics using neural networks considerably improves miss distance calculations.

MULTILEVEL DATA ASSOCIATION FOR THE VESSEL TRAFFIC SERVICES SYSTEM AND THE JOINT MARITIME COMMAND INFORMATION SYSTEM

Ian Neil Glenn-Major, Canadian Armed Forces
B. Eng., Royal Military College of Canada, 1982
Master of Science in Electrical Engineering-December 1995
Advisor: Murali Tummala, Department of Electrical and Computer Engineering

This thesis develops an algorithm to fuse redundant observations due to multiple sensor coverage of a vessel. Fuzzy membership functions are used as a measure of correlation, and a fuzzy associative system determines which observations represent the same vessel. The result is a computationally efficient algorithm. The output of the system is a unique set of vessels identified by unique platform identifiers. Results of tests based on computer simulation of overlapping radar coverage show that the fusion algorithm correctly correlates and fuses the sensor observations. That the VTS system is a subset of the Joint Maritime Command Information System (JMCIS) and ultimately the Global Command and Control Software (GCCS) system makes this algorithm pertinent not only to the U.S. Coast Guard, but also to the Navy, DoD and other agencies such as the Canadian Navy that use this software.

DESIGN AND EVALUATION OF MINE AND UXO DETECTORS TO AUTONOMOUS MOBILE ROBOTS

Curtis J. Goodnight-Lieutenant, United States Navy
B.S., Naval Postgraduate School, 1996
Master of Science in Electrical Engineering-September 1996
Advisors: Xiaoping Yun, Department of Electrical and Computer Engineering
David Cleary, Department of Physics

The study focuses on the development of a light weight detector to be used for the purpose of mine / Unexploded Ordnance (UXO) detection. The detector was developed based upon a twin oscillator design, and the performance of this design was tested with respect to diameter of the sensing coil, operating frequency, and the number of turns of the sensing coil. The results of this study provide a field tunable, light weight, low power mine / UXO detector with significant range. The ability to equip a robot with this device and send it into the field will prove to be an invaluable asset to ongoing mine sweeping operations.

DEVELOPMENT AND VALIDATION OF A SECOND GENERATION VISIBILITY-BASED MODEL FOR PREDICTING SUBJECTIVE AND OBJECTIVE MINIMUM RESOLVABLE TEMPERATURE DIFFERENCE PERFORMANCE FOR STARING THERMAL IMAGING SYSTEMS

Michael S. Groen-Captain, United States Marine Corps
B.S., Calvin College, 1986
Master of Science in Electrical Engineering-December 1995
Master of Science in Applied Physics-December 1995
Advisors: Alfred W. Cooper, Department of Physics
Ron J. Pieper-Department of Electrical and Computer Engineering

Several models have been proposed to predict the minimum resolvable temperature difference (MRTD) performance of second generation thermal imaging systems (TIS) which incorporate staring focal plane arrays. It has been suggested that these models are not accurate for predicting the performance of second generation staring focal plane arrays which have severe phasing or sampling characteristics not amenable to linear modulation transfer function analysis. A second problem with these models is that they require a particular set of assumptions concerning the observer eye/brain recognition process, which limits their usefulness in the prediction of the performance for systems that incorporate automatic target recognition (ATR) devices. In this thesis, a new model is presented for predicting the MRTD performance of second generation thermal imagers based on a minimum threshold input contrast, and a contrast reduction

factor due to aliasing and blurring effects. The model makes no assumptions regarding the recognition process, which allows a separate threshold value to be defined for either a human or machine observer. The model incorporates aliasing concepts, and extends performance prediction beyond the nominal Nyquist rate of the system. The model's predictions are compared to the predictions of the current standard FLIR92 model and measured laboratory results for two different staring focal plane array imagers. In both cases, the model's predictions match measured results more closely than the predictions of FLIR92.

COMMUNICATION CRITICAL PATH FOR GPS-ASSISTED TDOA GEOLOCATION SYSTEM

Diane K. Gronewold-Lieutenant Commander, United States Navy
B.S., Eastern Illinois University, 1985
B.A., Eastern Illinois University, 1985
Master of Science in Electrical Engineering-December 1995
Advisors: Gus K. Lott, Department of Electrical and Computer Engineering
Randy L. Borchardt, Department of Electrical and Computer Engineering

A large number of network management techniques exist for planning and scheduling large and complex projects. One such technique, the Activity-on-Node Network, is applied to a prototype system developed by the Applied Research Lab at the University of Texas. This prototype system uses time-difference-of-arrival techniques and the Global Positioning System (GPS) within a time-of-arrival algorithm for computing the geolocation of a target transmitter. A critical path is determined for a single transmitter geolocation. This paper defines the content and format for each required message among the network users, and investigates the impact of available communication bandwidth on geolocation fix rate.

COUNTERBATTERY DETECTION AND LOCATION FROM THE SEA USING THE AN/SPY-1 RADAR SYSTEM

James Wesley Hammond III-Major, United States Marine Corps
B.S., United States Naval Academy, 1982
Master of Science in Systems Engineering-September 1996
Advisor: D. Curtis Schleher, Information Warfare Academic Group
Second Reader: Rasler W. Smith, Department of Electrical and Computer Engineering

With a reawakening in littoral operations, there has been an increasing emphasis in revitalizing the U. S. Navy's Naval Surface Fire Support (NSFS) capability. This has primarily centered around improvements to weapon systems, but it must also include the other elements of a fire support system including target acquisition. One of the most successful systems in the ground battlefield environment, as evidenced by actions during Operation Desert Storm, has been the U. S. Army and Marine Corps Firefinder radars which can detect and locate firing positions of enemy indirect fire weapons so that enemy batteries can be quickly engaged. NSFS must substitute for the full spectrum of the ground fire support system until it can emplace ashore and then should augment it once it is ashore. Operations and contingencies of the last 15 years have demonstrated the need for a seamless capability of fire support, including target acquisition and especially counterbattery detection and location, across the complex sea-land interface. The AEGIS AN/SPY-1 radar, on cruisers and destroyers, has a similar phased array radar as the Firefinder system, which is the key to its success. This thesis looks at how the various models of this radar could be modified to perform the counterbattery mission with special emphasis on the problem of land clutter. The radar's integration into the entire amphibious force's fire support command and control network and the requirements for any future radar system are also addressed.

OPTIMAL LINEAR QUADRATIC GAUSSIAN CONTROLLER DESIGN FOR A FLEXIBLE-SPACECRAFT SIMULATOR

William Burke Harrington, Jr.-Lieutenant Commander, United States Navy
B.S., Marine Engineering, United States Naval Academy, 1985
Master of Science in Electrical Engineering-December 1995
Advisor: Roberto Cristi, Department of Electrical and Computer Engineering

The experimental verification of active control methods for vibration suppression of large flexible structures in space is essential for precision optical and military payload operations. The Flexible-Spacecraft Simulator (FSS) at the Naval Postgraduate School is designed for testing such control designs. The experimental setup simulates the pitch axis motion of a rigid body spacecraft with a flexible antenna support structure connected to a rigid reflector. A twenty-four state finite element analytical model is used to characterize the flexible appendage. Piezoelectric sensors and actuators are used for feedback control for fibration suppression. In addition, an external infrared camera provides direct feedback of the flexible structure's elbow and tip displacements and rotations. A Multiple-Input-Multiple-Output (MIMO) linear quadratic gaussian (LQG) controller is designed using linear quadratic regulator (LQR) optimal control theory and an optimal Kalman estimator as the state observer to meet desired performance specifications. The objective is to minimize the motion of the reflector.

ANALYSIS AND DESIGN OF CMOS VOLTAGE-FOLDING CIRCUITS AND THEIR USE IN HIGH SPEED ADCS

Troy L. Hart-Lieutenant Commander, United States Navy
B.S., Electrical Engineering, Auburn University, 1985
Master of Science in Electrical Engineering-June 1996
Advisor: Phillip E. Pace, Department of Electrical and Computer Engineering

This thesis provides a complete numerical analysis of a complementary metal-oxide semiconductor (CMOS) analog folding circuit architecture, which is comprised of a number of parallel folding stages connected to an output stage. The bias point (reference voltage at which input signal is to be folded) and differential input responses are determined analytically. Current source requirements are also determined to ensure that the transistors remain in saturation. Using the analysis, a design process for implementing the folding circuit as a preprocessor for an analog-to-digital converter (ADC) is developed. A folding circuit preprocessor for a 6-bit optimum symmetrical number system (SNS) ADC is designed using this process. The designed circuit output is numerically analyzed and compared with HSPICE simulation results to verify the design process. Transfer function results are evaluated numerically to examine the preprocessor performance. Decimation bands are utilized within the ADC to eliminate coding errors. The effects of fabrication process tolerances, which alter the metal-oxide semiconductor field-effect transistor (MOSFET) parameters used in the analysis and design of the circuit, are quantified using a four-corner approach.

AN/SRS-1 (COMBAT DF) AND THE JOINT MARITIME COMMAND INFORMATION SYSTEM (JMCIS): A CASE FOR LINKING

Stephen P. Heineman-Lieutenant Commander, United States Navy
B.S., University of Pennsylvania, 1982
Master of Science in Systems Engineering-September 1996
Advisors: Herschel H. Loomis, Jr., Department of Electrical and Computer Engineering
Vicente C. Garcia, Department of Electrical and Computer Engineering

U.S. Navy's AN/SRS-1 (COMBAT DF) is being introduced into the fleet aboard the LHD-1 and DDG-5 1 classes of ships. This shipboard cryptological system provides the capability to conduct signals exploitation over a wide range of frequencies. This system represents a significant improvement in capability over the OUTBOARD system installed aboard DD-963 class ships. When first conceived, COMBAT DF was designed as a stand alone system with limited off-ship connectivity through which to transmit or receive tactical locating and targeting information on Signals of

Interest (SOI). JMCIS is the latest effort of the U.S. Navy to produce an all encompassing Command, Control, Communications, Computers and Intelligence (C⁴I) system with global connectivity. This paper attempts to present the problems with COMBAT DF connectivity and how by linking COMBAT DF with JMCIS, the ability of the warfighter to conduct warfare will be enhanced. This is accomplished through the real-time transmission of tactical information via a computer-to-computer network.

RADIATION PATTERN CALCULATION FOR MISSILE RADOMES
IN THE NEAR FIELD OF AN ANTENNA

Scott M. Herzog-Lieutenant, United States Navy
B.S.A.A.E, The Ohio State University, 1988
Master of Science in Aeronautical Engineering-September 1996
Advisor: David C. Jenn, Department of Electrical and Computer Engineering
Second Reader: Robert E. Ball, Department of Aeronautics and Astronautics

An analytical model and computer simulation are presented for a radome located in the near field of an antenna. Using the computer code described here, design tradeoffs can be performed between electrical, structural, and aerodynamic properties of the radome. The code is based on a method of moments solution to the E-field integral equation for bodies of arbitrary shape. Measured radiation patterns for AGM-88 High Speed Antiradiation Missile (HARM) and AIM-SIC missile radomes are compared to computed data.

A COMPARISON BETWEEN POWER LINE NOISE LEVEL FIELD
MEASUREMENTS AND MAN-MADE RADIO NOISE PREDICTION
CURVES IN THE HIGH FREQUENCY RADIO BAND

James W. Hodge, Jr.-Captain, United States Marine Corps
B.S., Texas A&M University, 1989
Master of Science in Electrical Engineering-December 1995
Advisor: Richard W. Adler, Department of Electrical and Computer Engineering

Radio frequency noise is often the limiting factor in the ability of a communications receiver to discern a desired signal from man-made interference. The predominate man-made radio noise source in the high frequency radio band is gap type breakdown discharges on electric power distribution lines. The International Radio Consultative Committee (CCIR) has published its Report 258 which predicts the level of man-made radio noise in the business, residential, rural, and quiet rural environmental categories.

This thesis compares field measurements of gap type breakdown discharge generated noise, made in the high and very high frequency radio bands, to CCIR Report 258 predictions. It is shown that CCIR noise-level predictions correspond to field measurements in the low end of the high frequency band. At higher frequencies the CCIR curve consistently predicts a lower noise-level than was measured in the field. An explanation for the difference between field measurements and CCIR predictions is presented.

A trend noticed in the noise-amplitude versus receiver bandwidth data measurements is investigated and leads to the development of a receiver bandwidth adjustment matrix. Using this matrix the noise-power measurements made in one receiver bandwidth can be scaled to a different bandwidth.

ES-3A EXPLOITATION OF NATIONAL RECONNAISSANCE ASSETS
John M. Hood-Lieutenant, United States Navy
B.A., University of Florida, 1989
Master of Science in Systems Technology (Space Systems Operations)-September 1996
Advisors: Kyle T. Alfriend, Space Systems Academic Group
Vicente C. Garcia, Department of Electrical and Computer Engineering

Integrating national and tactical intelligence systems is an important priority in our National Security Strategy. Until recently though, national and tactical sensors operated separately. National systems focused on strategic priorities with little thought given to the needs of warfighters. But as Desert Storm demonstrated, national and tactical reconnaissance platforms, operating jointly, are critical in providing threat warning and precision targeting. Operating individually, national and tactical platforms suffer various limitations. When integrated, a synergy is achieved allowing the full potential of each component to be realized. In accordance with this warfighting trend, the ES-3A tactical signals intelligence aircraft will soon be equipped with the capability to directly receive intelligence from national assets. Little thought has been given as to what this new capability implies, especially in terms of how it will change the way the ES-3A is employed. Therefore, this thesis will discuss the kinds of intelligence the ES-3A mission commander can expect to receive from national systems, how that data will be delivered to the aircraft, how it is fused with intelligence derived from on-board sensors, and finally how this fused product can be used to accomplish mission tasks.

RADIATED POWER CONTROL FOR NARROW-BAND DIGITAL LINKS
Hsien-Ming Hsu-Lieutenant Commander, Republic of China, Taiwan Navy
Master of Science in Electrical Engineering-March 1996
Advisor: Chin-Hwa Lee, Department of Electrical and Computer Engineering

Radiated power control is one way to increase the capacity of a narrow-band channel with channel reuse. But channel reuse introduces the problem of a co-channel interference. Use of a power control algorithm not only can optimize the radiated power for a particular quality of service (QOS) but also minimize co-channel interference at the receiver.

In this thesis, we present the experimental results that relate the dependency of the logarithm of bit error rate (BER) versus the logarithm of the ratio of the energy per bit to the one-sided noise power spectral density (E_b/N). The dependency of BER to E_b/N_0 in an ideal and to E_b/N in a nonideal thermal noise limited receiver were analyzed. One important step in the analysis is the procedure of curve fitting used to characterize the radiated power for a particular system. In addition, we perform the experiments of BER measurement with a fixed power at a fixed location and the experiment to obtain the relationship between BER and the transmission distance with fixed radiated power. A curve fitting procedure to find the selected system parameter r is based on the results of BER measurement at fixed distance with variable power. The fixed step power control algorithm is also presented here. Experimental results are shown and compared to results expected from theory.

SPEED, POWER CONSUMPTION, AND IMPEDANCE IN GALLIUM ARSENIDE IC INTERCONNECTION CIRCUITS
Hugh Joseph Huck III-Lieutenant, United States Navy
B.S.G.E., United States Naval Academy, 1990
Master of Science in Electrical Engineering-September 1996
Advisor: Douglas J. Fouts, Department of Electrical and Computer Engineering
Second Reader: Todd R. Weatherford, Department of Electrical and Computer Engineering

The goal of this project is to determine the feasibility of conserving power while maintaining reasonably high speed in Gallium Arsenide integrated circuit interconnection circuits by increasing the characteristic impedance of microstrip or stripline printed circuit board. This thesis presents the modeling and simulation of output driver and input receiver circuits for Gallium Arsenide digital ICs. Impedance controlled printed circuit board transmission lines are also studied. MATLAB is used to model and calculate the impedance that can be obtained using a microstrip and/or stripline printed circuit board interconnect. This information is then used with HSPICE to model and simulate transmission line

interconnects. HSPICE is also used to model and simulate the design of the output driver and input receiver circuits for use with the printed circuit board. Finally, the IC is laid out using MAGIC to show differences in circuit size at different impedances.

THE USE OF HÉNON BINARY SEQUENCES FOR DIRECT SEQUENCE SPREAD SPECTRUM CODE GENERATION

Linda M. Hunter-Lieutenant Commander, United States Navy
B.S., United States Naval Academy, 1987
Master of Science in Systems Technology (Space Systems Operations)-September 1996
Master of Science in Applied Mathematics-September 1996
Advisors: Herschel H. Loomis, Jr., Department of Electrical and Computer Engineering
Harold M. Fredricksen, Department of Mathematics

In this thesis, the generation of secure codes using chaotic pseudo-random sequences and a generalized Geffe generator is investigated. These codes are tested for cryptographic security and applicability for use in a spread spectrum communications system. It is shown that the codes appear to be cryptographically sound and suitable for use in a multi-user environment, but do not significantly enhance the security of the spread spectrum system. Further simulation of the spread spectrum system is utilized to investigate the effect of errors in receiver spreading codes.

VULNERABILITY STUDY OF THE SITUATIONAL AWARENESS BEACON WITH REPLY

Sandra M. Jamshidi-Lieutenant, United States Navy
B.S., United States Naval Academy, 1988
Master of Science in Systems Technology, (Space Systems Operations)-September 1996
Advisors: Herschel H. Loomis, Jr., Department of Electrical and Computer Engineering
Vicente C. Garcia, Jr., Department of Electrical and Computer Engineering
Second Reader: Raymond F. Bernstein, Jr., Department of Electrical and Computer Engineering

This thesis is an evaluation of the vulnerabilities of the Situational Awareness Beacon with Reply (SABER) System from the perspective of an enemy force. The system design is described to provide the understanding necessary to evaluate the vulnerabilities. It provides the background of SABER's development and information on the concept of operations and system requirements. It includes a description of the fundamentals and definitions associated with the general vulnerabilities common to all communications systems which can be exploited by enemy forces. After establishing the methodology from which the system is viewed, the external vulnerabilities of the Global Positioning System (GPS) and UHF satellite communications (SATCOM) are discussed. It provides details on the extent of the vulnerabilities specific to SABER which could be exploited by a "technically feasible" enemy. The vulnerabilities are summarized on the basis of a nodal analysis. Recognizing that vulnerabilities must be considered in conjunction with threats, risks, and the impact to operational readiness, it provides some discussion on steps which must follow the vulnerability analysis. Recommendations for the SABER 1 production level model are provided with a list of potential areas for future research.

TIME-DIFFERENCE-OF-ARRIVAL ESTIMATION USING CYCLOSTATIONARY SIGNAL PROCESSING TECHNIQUES (PART I/PART II)

Douglas A Jenik-Lieutenant, United States Navy
B.S., Texas Tech University, 1987
Master of Science in Electrical Engineering-March 1996
Advisors: Herschel Loomis, Jr., Department of Electrical and Computer Engineering
Chad M. Spooner, Mission Research Corporation

Time-Difference-of-Arrival (TDOA) estimation is the estimation of the relative time difference observed in the reception of a signal that impinges on two spatially separated receivers. Conventional approaches to estimating TDOA values have primarily consisted of exploiting the properties inherent in the simple cross-correlation function which ideally exhibits a peak at the TDOA value. Though conventional methods produce very sound results in many instances, they suffer from important intrinsic shortcomings. Co-channel interference and strong noise can adversely affect these methods resulting in estimate ambiguities and inaccuracies. Development of the Spectral Coherence Alignment (SPECCOA), Generalized Spectral Coherence Alignment (GSPECCOA), and Maximum Likelihood (ML) algorithms has provided a means to overcome these deficiencies through exploitation of the cyclostationary nature of signals. These signal processing algorithms possess a signal-selectivity property that renders them inherently more tolerant to noise and interference. This thesis contains a performance comparison of conventional and cyclostationary-based techniques demonstrating the efficacy of this highly desirable property under controlled, simulated environments and on real-world collected data and presents an assessment of the potential for future applications.

WIDEBAND SIGNAL ANALYSIS AND SYNTHESIS APPLIED TO ELECTROMAGNETIC TRANSIENT WAVEFORMS

Soonho Jeong-Captain, Republic of Korea. Army
B.S., Korea Military Academy, 1990
Master of Science in Electrical Engineering-March 1996
Advisor: Murali Tummala, Department of Electrical and Computer Engineering

This thesis presents the bandpass inverse fast-Fourier transform (IFFT) filter bank and the multirate digital filter bank techniques to synthesize test point waveforms from constituent waveforms recorded by two instruments as part of an aircraft electromagnetic hardness evaluation test. The component waveforms are recorded by two separate measurement systems (High-Powered Pulse Waveform (HPW) in the time domain and Continuous Sweep Waveform (CSW) in the frequency domain) under two different aircraft orientations (parallel and perpendicular). Data from two orientations are combined using the sinusoidal modeling algorithm (SMA). The tree-structured filter bank with power symmetric overlap method and the bandpass IFFT with spectral concatenation method are developed to further combine these waveforms with an overlapping frequency spectrum to produce the corresponding synthesized test point waveform.

GEOLOCATION WORKBENCH DEVELOPMENT SYSTEM

Brian K. Jones-Lieutenant Commander, United States Navy
B.S., University of Southern Colorado, 1985
Master of Science in Computer Science-September 1996
Advisors: Timothy J. Shimeall, Department of Computer Science
Herschel H. Loomis, Jr., Department of Electrical and Computer Engineering

This thesis provides a common signal abstraction for the geolocation workbench. The geolocation workbench is a software tool used to develop, modify and test geolocation algorithms. Electronic signals come from a variety of

sources, in many different formats and with different descriptive parameters. This has been a hindrance to the development of geolocation and signal processing algorithms.

The approach taken was to examine existing signal formats and synthesize a common format to be used within the geolocation workbench. Utilizing object-oriented techniques a signal class hierarchy was developed consisting of a SIGNAL class and sub-classes of Pulse Descriptor Word and Digital IF signals.

The results of this thesis are a common abstraction for representing signals, and high level design for the Signal Management functions of the Workbench. This abstraction provides access for a broad class of algorithms to access signal data sets. The storage of signal sets in both their raw format and the converted format facilitates the development of geolocation algorithms as well as filtering and signal processing algorithms.

DESIGN AND IMPLEMENTATION OF A GEOLOCATION SOFTWARE WORKBENCH
Gregory Ian Jones-Lieutenant, United States Navy
B.A., University of Florida, 1988
Master of Science in Engineering Science-March 1996
Advisors: Herschel H. Loomis, Jr., Department of Electrical and Computer Engineering
Sandra Lynn Scrivener, Department of Aeronautics and Astronautics

This thesis explores the background and concerns involved in creating a multipurpose software tool that can be used to process electronic signals in an effort to determine the signal's point of origin. A functional workbench utilizing stand-alone software modules was constructed using the MATLAB® software environment. Specific emphasis was placed upon the following aspects: determining the formats for, and actually coding, input and output data file interfaces, propagation path error accounting, geolocation algorithm implementation, arid graphical user interface design. A well-known geolocation method, Time Difference of Arrival (TDOA), was chosen to be the Geolocation Workbench's first example. The result of this effort is a working software model that demonstrates how this workbench can be used effectively by geolocation algorithm developers and geolocation end users alike.

AUTOMATIC SYNTHETIC SONAR TRANSIENT GENERATION
Michael C. Jones-Lieutenant, United States Navy
B.S.C.S., United States Naval Academy, 1988
Master of Science in Electrical Engineering-December 1995
Advisor: Charles W. Therrien, Department of Electrical and Computer Engineering

This thesis addresses the problem of extending and available data base of sonar transients by analysis/synthesis methods. Two specific methods are considered and automated for this purpose: a stochastic method and a stochastic/deterministic method. The stochastic method employes a time varying Burg algorithm to model the original signals, then stores the essential parameters in a database. Once all of the original signals are in this database, the segments of the original signals are mixed in a natural format to produce a synthetic signal unlike any original signal yet possessing the aural, spectral, and temporal characteristics of the class. The stochastic/deterministic method uses an ARMA model to extract the most significant time varying harmonics from the original signal then employs the same time varying Burg algorithm to model the remainder of the signal. The parameters are stored and used to create synthetic signals in the same manner as the stochastic method. Results of the two methods are compared.

AR PARAMETER ESTIMATION USING TMS320C30
DIGITAL SIGNAL PROCESSOR CHIP

Mücahit Karasu-Lieutenant Junior Grade, Turkish Navy
B.S., Turkish Naval Academy, 1989
Master of Science in Electrical Engineering-December 1995
Advisor: Michael K. Shields, Department of Electrical and Computer Engineering

Autoregressive analysis is used in modern signal processing applications for modeling and estimation of random signals. High speed digital signal processors with advanced architecture and special digital signal processing instructions, mostly compiled in C language, can be used in these applications to achieve realtime performance. A commercially available digital signal processor has been used in this work to estimate the AR parameters and power spectral density from the given input data by using the Levinson, Burg and Schur algorithms. This work produced a library file that contains the object files of the AR parameter estimation algorithms. The time required in terms of the cycle counts to execute each algorithm is listed for different data lengths and model orders.

THE MODIFICATION OF A SURFACE SHIPBORN RADAR (DECCA 1226)
IN ORDER TO MEET MILITARY STANDARDS (HIGH RESOLUTION)
WITHOUT CHANGING ITS ELECTRONIC SIGNATURE

Dimitrios Kavoulakos-Lieutenant Junior Grade, Hellenic Navy
B.S., Hellenic Naval Academy, 1987
Master of Science in Electrical Engineering-March 1996
Advisor: Fred Levien, Department of Electrical and Computer Engineering
Second Reader: Charles W. Therrien, Department of Electrical and Computer Engineering

This is a theoretical study examining the possibility to use a commercial, shipborne navigational radar, for target classification and identification, without changing its electronic signature. The reason for such a modification is that using sophisticated pulse forms for target recognition can betray the user's presence and give an intelligence advantage to potential enemy platforms.

In order to extract a target's class or identity, the data of the radar's video detector are fed to a high performance PC with digitizing capability. There the target's class is obtained through a series of transforms, while the target's identity is obtained by computing the target's frequency response to a very short pulse using the MUSIC method. While the classification process does not require any changes in the transmitter, in order to obtain target identification in tactically useful ranges it is necessary to increase the transmitter's power and add an additional very short pulse.

TACTICAL NAVAL APPLICATIONS OF THE "IMPROVED MANY-ON-MANY"
RADAR SIMULATION PROGRAM

Stanley Ollie Keeve, Jr.-Lieutenant, United States Navy
B.S., College of New Jersey, 1988
Master of Science in Electrical Engineering-September 1996
Advisor: Frederic H. Levien, Department of Electrical and Computer Engineering
Second Reader: Phillip E. Pace, Department of Electrical and Computer Engineering

The "Improved Many-on-Many" (IMOM) radar simulation modeling program was developed and is used by the United States Air Force for mission planning of its tactical aircraft. Although the U. S. Navy has a similar software product designed for its tactical aircraft, it currently does not use any radar simulation modeling program specifically designed to strategically position its surface fleet of frigates, destroyers, cruisers, carriers, and amphibious ships. The U. S. Navy's new focus on operations in the littoral environment requires surface ships to operate in regions that present greater challenges to a carrier or amphibious battlegroup. Surface ship commanders need radar simulation tools to allow them to quickly and accurately model enemy radar installations, expected radar ranges, and weapons envelopes.

The purpose of this thesis is to evaluate the potential adaptability of IMOM in a surface navy planning role. Particular attention is paid to how the littoral environment affects surface radar.

LINEAR MODELING OF TILTROTOR AIRCRAFT (IN HELICOPTER AND AIRPLANE MODES) FOR STABILITY ANALYSIS AND PRELIMINARY DESIGN
Gary D. Klein-Captain, United States Marine Corps
B.S., Aerospace Engineering, United States Naval Academy, 1985
Master of Science in Electrical Engineering-June 1996
Master of Science in Aeronautical Engineering-June 1996
Advisors: Robert G. Hutchins, Department of Electrical and Computer Engineering
E. Roberts Wood, Department of Aeronautics and Astronautics

This thesis investigates the linear state space modeling of a tiltrotor aircraft by modifying an existing MATLAB routine which is used for preliminary (helicopter) stability and control analysis. The modifications consist of changing existing script files along with adding new ones. The modifications result in having a routine that allows the input of tiltrotor characteristics and subsequently generates a state space model along with other stability and control characteristics. The tiltrotor modeling is validated by the input of XV-15 characteristic data into the program and performing a eigenvalue comparison with a model of a similar tiltrotor, the V-22. A more extensive comparison is performed with another XV-15 model which has been extensively used and validated with wind tunnel and flight.

BROADBAND HF AND VHF ANTENNA DESIGN WITH TERRAIN MODELING
Theodore S. Kline-Captain, United States Marine Corps
B.S., Pennsylvania State University, 1987
Master of Science in Electrical Engineering-December 1995
Advisors: Rasler W. Smith, Department of Electrical and Computer Engineering
Richard W. Adler, Department of Electrical and Computer Engineering

The objective of this thesis was the design and analysis of broadband antennas to be used with sounders for transequatorial propagation research. Sites have been identified in Oahu and Rarotonga. A four step process is used in the design of the antennas. The four steps are: theoretical design, preliminary analysis with ELNEC software, detailed analysis with NEC-4 software and finally terrain modeling with PAINT, MN and TA software.

Preliminary work led to the decision to use two antennas at each site. On Oahu a HF log-periodic antenna is used for the 2-25 MHz band and a VHF log-periodic antenna is used for the 25-60 MHz band. On Rarotonga a VHF log-periodic antenna is also used for the 25-60 MHz band, however a sloping V antenna is used for the 2-25 MHz band. Computer generated impedance values and radiation patterns are presented.

MODELING AND EXPERIMENTAL TESTING FOR FUTURE DEVELOPMENT OF NIGHT VISION ELECTRO-OPTIC (NVEO) FLIR92 MODEL
Cem Koc-Lieutenant Junior Grade, Turkish Navy
B.S.E.E., Turkish Naval Academy, 1989
Master of Science in Systems Engineering-December 1995
Advisor: Ron J. Pieper, Department of Electrical and Computer Engineering

Recent advances in thermal imaging technology have resulted in the fielding of two-dimensional array detector based imaging systems. These designs have been labeled second-generation, and are rapidly replacing first generation systems having linear detector arrays with a parallel scan type architecture. It has been postulated that first generation prediction models are not applicable to second generation systems. In particular, the minimum resolvable temperature difference (MRTD) modeling needs refinement in the areas of sampling, quantization noise, and array non-uniformities in order for it to be applied to second generation systems. The present industry standard for MRTD is the Night

Vision FLIR92 Model. Results from the FLIR92 Model and the two well known first generation models will be presented and compared with experimental measurements made on two thermal imaging systems available at the Naval Postgraduate School.

INTERCEPTING A COVERT NAVAL RADAR
Thomas A. Kubista-Lieutenant, United States Navy
B.S., United States Naval Academy, 1989
Master of Science in Systems Engineering-September 1996
Advisor: D. Curtis Schleher, Information Warfare Academic Group
Second Reader: David Jenn, Department of Electrical and Computer Engineering

Radars with low probability of intercept (LPI) characteristics present a considerable threat to current electronic support measures (ESM) receivers. A radar with LPI characteristics could conceivably track a target without ever being detected. The Pilot class of marine radars has just such a claim. Developed in 1986, the Pilot class of covert radars are being sold on the world market by Celsiustech as the *Pilot Mk 2* and by Signaal as the *Scout*. The Pilot class of radar uses a frequency modulated continuous wave (FMCW) carrier and very low power to remain virtually undetectable while painting targets as far as 25 miles away. This thesis assesses the LPI threat and describes how the Pilot radar is rapidly emerging as a new class of LPI radars. It tests the Pilot's claim of "indetectability" by evaluating the Pilot waveform against the ALR-81(V)3, one of the U.S. Navy's most sensitive and versatile Electronic Intelligence (ELINT) receivers. Designed and built by Condor Systems, the ALR-8 1(V)3 scanning superheterodyne receiver is part of the electronic warfare (EW) suite aboard the ES-3A Sea Shadow reconnaissance plane. A test conducted in cooperation with Condor Systems demonstrated the performance of the actual ALR-8 1 (V)3 receiver hardware verses a simulated Pilot radar waveform.

USING EXPERT SYSTEMS TO CONDUCT VULNERABILITY ASSESSMENTS
Debra A. Lankhorst-Lieutenant, United States Navy
B.S., University of North Carolina at Greensboro, 1984
Master of Science in Information Technology Management-September 1996
Advisors: Carl Jones, Department of Systems Management
Vicente C. Garcia, Department of Electrical and Computer Engineering

An Information Warrior faces a complex and dynamic operating environment. To conduct an accurate Vulnerability Assessment and Risk Analysis of the enemy force (or a friendly force), a multitude of cause and effect relationships must be examined. Many times the person at the battle scene conducting the assessment may lack experience and/or knowledge, precluding a time-sensitive and effective assessment. The author proposes a framework for a global network of expert systems and decision support systems to conduct the Vulnerability Assessments and maintain Information Warfare readiness through realistic training. The author also presents a Vulnerability Assessment and Risk Analysis heuristic with the objective of expanding the knowledge base and decision speed at the on-scene commander level. In achieving and implementing this global network, numerous benefits can be realized, including increased speed and efficiency in the receipt of intelligence information, thereby allowing for improved decision-making capabilities. Since the technology and know-how are already available, this vision of the global network is attainable and can be successfully implemented and operated.

USE OF THE SYMMETRICAL NUMBER SYSTEM IN RESOLVING UNDERSAMPLING ALIASES

Richard E. Leino-Captain-United States Marine Corps
B.S., Rensselaer Polytechnic Institute, 1990
Master of Science in Electrical Engineering-September 1996
Advisor: Phillip E. Pace, Department of Electrical and Computer Engineering
Second Reader: David Styer, Department of Mathematical Sciences, University of Cincinnati

Two algorithms are presented which allow for the unambiguous resolution of multiple undersampled frequency components in a signal. Digital signal processing is usually governed by the Nyquist criterion which limits the amount of information that can be unambiguously stored and recovered digitally to a spectral width no larger than half the sampling frequency. Both algorithms resolve a spectrum beyond Nyquist by using additional information. The first method samples a signal more than once using a different sampling frequency each time. The second method utilizes a single sampling frequency which is used to sample both the signal and a band-limited version of the signal. When using multiple sampling frequencies, each sampling frequency yields a digital sequence which, in turn, has a unique spectrum when the Discrete Fourier Transform (DFT) is applied. The bin and amplitude information from each of the resulting undersampled spectra is then recombined to resolve the original spectrum. In like manner, when using a single sampling frequency the spectra of both the signal and its band-limited version are recombined to obtain the solution. Given a sampling frequency, both algorithms allow for the unambiguous resolution of a signal with a spectral width at least twice as large as that predicted by Nyquist.

ENSURING A C2 LEVEL OF TRUST AND INTEROPERABILITY IN A NETWORKED WINDOWS NT ENVIRONMENT

Julie A. Lucas-Lieutenant, United States Navy
B.S., Ohio State University, 1988
Master of Science in Information Technology Management-September 1996
Advisors: Gus Lott, Department of Electrical and Computer Engineering
Cynthia E. Irvine, Department of Computer Science
Rex Buddenberg, Department of Systems Management

With the progression of computer systems to local and wide area networks, the scope of computer security has increased dramatically over the past two decades. Now, more than ever, the use of "trusted systems" is needed to ensure the secrecy, integrity, and availability of computer resources. However, attaining the levels of trust required has been difficult for a variety of reasons. This paper provides an in-depth look at the government's Trusted Computer System Evaluation Criteria (TCSEC) and its current applicability. An analysis of a military network running Windows NT version 3.51 as the network operating system is provided as a case study. The paper concludes with a discussion of the advantages and disadvantages of the TCSEC criterion. Although products have been certified as meeting the various class requirements, existing problems are preventing the attainment of "trusted" system from becoming a reality for many government organizations.

THE FEASIBILITY OF USING TETHERED SATELLITES FOR GEOLOCATION

Kern D. Lunde-Lieutenant Commander, United States Navy
B.A., University of Wisconsin, 1985
Master of Science in Engineering Science-September 1996
Advisors: Herschel H. Loomis, Jr., Department of Electrical and Computer Engineering
Vicente C. Garcia, Department of Electrical and Computer Engineering

Geolocation from space of signals using Time-Difference-of-Arrival (TDOA) methods requires two or more satellites; for low earth orbiting satellites, orbital dynamics dictates that the satellites be in a 'lead-trail' configuration. This configuration limits the geometry for geolocation. The use of a pair of tethered satellites ('high-low' configuration)

makes possible another geometry for geolocation. Although tethered satellites have other possible applications worthy of pursuit, a comparison of calculated geolocation accuracy with the current 'lead-trail' configuration is the focus of this thesis.

VELOCITY COMPENSATION IN STEPPED FREQUENCY RADAR

Yu-Bin Ma-Major, Republic of China Army
B.S.E.E., Chung Cheng Institute of Technology, 1987
Master of Science in Electrical Engineering-December 1995
Advisor: Gurnam S. Gill, Department of Electrical and Computer Engineering

As compared to the commonly used constant frequency radar waveforms, the stepped-frequency waveform can achieve high range resolution while still retaining the advantages of lower instantaneous receiver bandwidth and lower analog-to-digital sampling rate. However, the relative radial motion between the target and the stepped-frequency radar will result in performance degradations, such as range error, loss in signal-to-noise ratio, and degraded range resolution. The solution to this problem is to apply velocity compensation to the received signal, which can eliminate the degradations due to Doppler effects. Three velocity compensation schemes for the detection of a moving target in clutter are designed, discussed, and compared in this thesis. Also, a simulation is presented to verify the concepts, and simulation results are compared and discussed.

AUTONOMOUS CONTROL OF UNDERWATER VEHICLES AND LOCAL AREA MANEUVERING

David Bryan Marco-Civilian
B.S., Oklahoma State University, 1983
M.S. University of Texas at Austin, 1987
Doctor of Philosophy in Mechanical Engineering-September 1996
Advisors: Anthony J. Healey, Department of Mechanical Engineering
Robert Cristi, Department of Electrical and Computer Engineering
Robert B. McGhee, Department of Computer Science
Fotis A. Papoulias, Department of Mechanical Engineering
Louis V. Schmidt, Department of Aeronautics and Astronautics

The major thrust of this work is the development and demonstration of new capabilities for the use of small autonomous vehicles in mine countermeasure applications. Key to the new capabilities lies in an open architecture tri-level software structure for hybrid control, of which this work is the first validated implementation. The two upper levels run asynchronously in computing logical operations based on numerical decision making, while the lowest, the Execution Level, runs synchronously to maintain stability of vehicle motion. The top (Strategic) Level of control uses Prolog as a rule based language for the specification of the discrete event system (DES) aspects of the mission. Multiple servo controllers are coordinated by the middle (Tactical) Level software in performing the mission, while the Execution Level controllers guarantee robust motion stability through multiple sliding modes.

This hardware/software arrangement provides the ability to operate a hybrid (mixed discrete state/continuous state) controller for semi-autonomous and autonomous vehicles in which the missions imply multiple task robot behavior. This work has defined and developed a set of vehicle "primitives", that are a set of stable modular control functions unique to a given vehicle's capabilities. It is demonstrated how these can easily be combined using rules to specify as simple, or as complex, a mission as desired. Completion of a mission is guaranteed through a "complete plan" including time traps and error recovery procedures. Experimental results are given illustrating the performance attained.

A particular case of the technique developed has resulted in a method to navigate an AUV in a local area (around a mine-like object) using a profiling sonar sensor for position information derived from underwater feature detection. Since sonar image feature extraction is necessarily time consuming, a dynamic model of the vehicle response is used for control between position updates. A structured formulation of this control/navigation method is presented followed by results from in water implementation using the NPS Phoenix vehicle and the tri-level software structure described above.

SPEECH COMPRESSION USING COSINE PACKET DECOMPOSITION

Joao Roberto Vasconcellos Martins-Lieutenant Commander, Brazilian Navy
B.S.E.E., Universidade de Sao Paulo, 1986
Master of Science in Electrical Engineering-March 1996
Advisors: Monique P. Fargues, Department of Electrical and Computer Engineering
Ralph Hippenstiel, Department of Electrical and Computer Engineering

As digitization of data becomes more prevalent, the demands on existing communications networks and computer systems to cope with this increase become overwhelming. Currently, the speech compression problem is handled using the CELP (Code Excited Linear Prediction) scheme and its derivatives. Such techniques are the most frequently used for speech compression at medium-to-low ranges. Recent research conducted into the area of cosine packets has proven this field to be readily adaptable to speech compression and coding. In this thesis, speech compression schemes are developed using cosine-packet decomposition, minimum entropy basis selection, and an adaptive thresholding scheme for selecting coefficients. In addition, voiced-unvoiced segmentation and a denoising scheme are implemented. Test results show high compression ratios (1:50) with a good quality of reconstructed speech.

ACTIVE PHASED ARRAY RADAR ANALYSIS

Victor A. Micheli-Lieutenant Commander, Venezuelan Navy
B.S., Venezuelan Naval School, 1983
Master of Science in System Engineering-September 1996
Advisor: Chin-Hwa Lee, Department of Electrical and Computer Engineering
Second Reader: Gurman S. Gill, Department of Electrical and Computer Engineering

A phased array antenna can electronically steer the direction of the antenna beam almost instantaneously. In an Active Phased Array Radar (APAR), this capability is used to allow the system to multiplex its time between many different functions; the primary functions are search and target tracking. Potentially, the APAR can be designed based on the task it is performing, such that any savings in radar time in meeting the requirement of one task allow that time to be devoted beneficially to other tasks. The primary goal of this research is to investigate the performance assessment and improve the techniques for control of an Active Phased Array Radar performing the tracking function. In order to reliably and efficiently track targets, a MS. Excel 5.0 Spread Sheet program is implemented so that tracking range must be rapidly changed. With this program we can explore the many degrees of freedom that future APAR's will bring, such as adaptable update rate, antenna beamwidth, transmitted power, frequency, etc.

SIMULATION OF AN OPTICAL CORRELATOR CONFIGURED AS AN IMAGING SYSTEM USING LIQUID CRYSTAL TELEVISION SPATIAL LIGHT MODULATORS

Scot C. Miller-Major, United States Army
B.S.E.E., New Mexico State University, 1983
Master of Science in Electrical Engineering-March 1996
Advisor: John P. Powers, Department of Electrical and Computer Engineering

This thesis models the complex transmittance effects of liquid crystal television spatial light modulators (SLMs) in an optical correlator configured as an imaging system. The computer model implements both the ideal transmittance and the nonlinear measure transmittance which is a function of the voltage applied across the pixel of the liquid crystal device. The system modeled included the effects of a nonlinear input SLM input but assumed an ideal filter SLM. Input waveforms included both one-dimensional and two-dimensional spatial cosines and chirped cosines. Results show that the effects of the SLM transmittance nonlinearity can be minimized by limiting the input signal voltages to values falling on a piecewise linear region of the transmittance operating characteristics.

HIGH-RESOLUTION RESIDUE ANTENNA ARCHITECTURES FOR WIDEBAND DIRECTION FINDING

Luis E. Rodrigues Moita-Lieutenant, Portuguese Navy
B.S., Portuguese Naval Academy, 1989
Master of Science in Applied Physics-June 1996
Advisors: Phillip E. Pace, Department of Electrical and Computer Engineering
Robert M. Keolian, Department of Physics

The performance of two novel interferometer antenna architectures for high-resolution, wideband direction finding are investigated. The first configuration incorporates a Symmetrical Number System (SNS) encoding of the interferometer amplitude response (symmetrical folding waveform). The second configuration incorporates a Residue Number System (RNS) encoding of the interferometer phase response (saw-tooth waveform). The residue architectures serve as a source for resolution enhancement in an interferometer array by decomposing the analog spatial filtering operation into a number of parallel sub-operations (moduli) that are of smaller computational complexity. Each sub-operation only requires a precision in accordance with the size of the modulus. A much higher resolution is achieved after the N moduli are used and the results of these low precision sub-operations are recombined. A four-element, 3 channel array using moduli set $m_1 = 3$, $m_2 = 4$ and $m_3 = 5$ was constructed in a ground plane using rectangular waveguide elements with a center frequency of 8.5 GHz. Experimental results are compared with the simulation results to demonstrate the advantages of this approach. The frequency response of the RNS array is investigated numerically. To correct the quantization errors due to any frequency offset, a fast correction algorithm is derived and is shown to have excellent results over a wide bandwidth.

DESIGN OF A SATELLITE-BASED MICROELECTRONIC RADIATION TESTING EXPERIMENT

Christopher S. Mooney-Lieutenant, United States Navy
B.S., University of Illinois at Urbana, 1987
Master of Science in Electrical Engineering-March 1996
Advisor: Douglas J. Fouts, Department of Electrical and Computer Engineering
Second Reader: Randy L. Borchardt, Department of Electrical and Computer Engineering

In this research, an electronic daughterboard to be used on the Microelectronics and Photonics Test Bed satellite was designed. A printed circuit board with radiation-hardened components was laid out to test various families of static RAM chips and an experimental Gallium-Arsenide integrated circuit. Computer-aided-design tools produced by Cadence Design Systems were used to logically and physically design the experiment. Output from the Cadence software provides the information necessary to fabricate, assemble, and test the board.

TACTICAL DMS: A GLOBAL BROADCAST SERVICE OPTION

Jose I. Morales-Lieutenant, United States Navy
B.S., United States Naval Academy, 1989
Master of Science in Systems Technology-June 1996
Advisors: Donald Wadsworth, Department of Electrical and Computer Engineering
Rex Buddenberg, Department of Systems Management
Carl Jones, Department of Systems Management

This thesis presents one possible method of integrating the DMS and GBS systems. This effort is undertaken in order to explore how the DMS messaging capability can be extended to the mobile, tactical user via a new, more robust broadcast subsystem. The Navy's current Fleet Broadcast subsystem is not prepared to handle the increased traffic load expected from the conversion to DMS-based messaging. The application of GBS as a "next generation" Fleet Broadcast offers an expansive leap in tactical broadcast communication capability.

DMS broadcast to the tactical environment via GBS is achieved through the application of relatively new, commercially developed network addressing and mobile-user routing protocols. Adaptation of a broadcast messaging capabil-

ity into the DMS is also incorporated. Incompatibility issues are resolved at the transport and network layers instead of higher-layer data format conversion. The proposed communications architecture provides for a high data-rate message broadcast system, capable of carrying DMS traffic to mobile units.

PLANARITY IN ROMDD'S OF MULTIPLE-VALUED SYMMETRIC FUNCTIONS
Jeffrey L. Nowlin-Lieutenant, United States Navy
B.S.E.E., Norwich University, 1989
Master of Science in Electrical Engineering-March 1996
Advisor: Jon T. Butler, Department of Electrical and Computer Engineering

An important consideration in the design of digital circuits is delay. A major source of delay in VLSI is interconnect. Crossings among interconnect require via's which cause resistance and additional delay. This thesis focuses on circuit design based on the reduced ordered multiple-valued decision diagram (ROMDD), a graph representation of a logic function. Crossings among edges in the ROMDD result in crossings in the circuit. Thus, ROMDD's without crossings reduce delay.

Since symmetric functions are important in the design of logic circuits, they are considered here. It is shown that a multiple-valued symmetric function has a planar ROMDD if and only if it is a pseudo-voting function. It is also shown that the number of such functions is $(r-1) \begin{pmatrix} n+r \\ n+1 \end{pmatrix}$, where r is the number of logic values and n is the number of variables.

It follows from this that the fraction of symmetric multiple-valued functions that have planar ROMDD's approaches 0 as n approaches infinity. Further, for planar ROMDD's of symmetric functions, it is shown that the worst case number of nodes is $n^2 \left[\frac{1}{2} - \frac{1}{(r+1)} \right]$ and the average number of nodes is $n^2 \left[\frac{1}{2} - \frac{1}{2r} \right]$, when n is large.

Additionally, multiple-valued *Fibonacci* functions are examined and conditions for planarity in their ROMDD representations are established.

SINGLE SOURCE ERROR ELLIPSE COMBINATION
Joseph R Orechovesky-Lieutenant, United States Navy
B.S., University of South Carolina, 1989
Master of Science in Systems Technology (Space Systems Operations)-September 1996
Advisor: Vicente Garcia, Department of Electrical and Computer Engineering
Second Reader: Gerry Baumgartner, NRaD

There are a number of military applications in which the geographic location of a signal of interest is of prime importance to the ability of a unit to fulfill its mission. The accuracy of the geographic fix provided to the warfighter can directly affect the success or failure of a mission. One method to improve the accuracy of existing systems is to use the weighted average of a number of intercepts. Each intercept is manifested as an error ellipse comprised of a latitude, longitude, semi-axes, heading and a related Chi-squared distributed probability. Individual error ellipses can be viewed as a quadratic surface perpendicular to the x,y plane of a bivariate normal distribution, the z-axis intersection of which corresponds to a Chi-squared value. By transforming the individual error ellipses to their related location covariance matrices, Gaussian statistics may be used to produce a single location ellipse that combines information from several two-dimensional target location ellipses. By providing a means to fuse data from a given source the warfighter or analyst will be able to more accurately assess a threat and respond.

RESEARCH ON MOTION PLANNING OF AUTONOMOUS MOBILE ROBOT
Athanassios Papadatos-Lieutenant, Hellenic Navy
B.S., Hellenic Naval Academy, 1985
Master of Science in Computer Science-March 1996
Advisors: Yutak J. Kanayama, Department of Computer Science
Xiaoping Yun, Department of Electrical and Computer Engineering

The path planning algorithm in Yamabico is based on a variation of Dijkstra's algorithm which has time complexity of $O(n^2)$. This algorithm works well in a dynamic environment, but a faster algorithm, called the All-Pairs Minimum Cost Paths algorithm, works even faster, $O(1)$, in the case of a static environment.

The computational complexity of the All-Pairs algorithm is $O(n^3)$, but if we know all pairs in advance, that is, the environment is static, we can preprocess them in advance, and use table lookup instead of Dijkstra's algorithm. Thus, we implemented a table lookup version for the static case, and kept Dijkstra's algorithm for the dynamic case. This results in both speed and flexibility.

This thesis also investigated the Linear Fitting Algorithm for Sonar testing. Range and angle data, from sonar, was fit to a straight line, giving resolution of 1 to 2.5 cm when the robot is within 100 to 150 cm of the line.

INTERPOLATION TECHNIQUES IN HIGH-RESOLUTION RESIDUE ANTENNA ARCHITECTURES
Byeong-Jun Park-Captain, Republic of Korea Army
B.S., Korea Military Academy, 1990
Master of Science in Systems Engineering-September 1996
Advisors: David C. Jenn, Department of Electrical and Computer Engineering
Phillip. E. Pace, Department of Electrical and Computer Engineering

A direction finding antenna based on residue number systems (RNSs) is presented. Special spacing requirements for the array elements are derived and processing of the array output for high speed direction of arrival (DOA) estimates is discussed.

The RNS antenna processor encodes the interferometer phase response, which is a sawtooth folding waveform. By design, the phase response of each element pair folds with folding period equal to the chosen modulus.

If DOA samples are generated by stepping the emitter direction between -90 and 90 degree in small increments, some samples will fall about the code transition points and result in encoding errors. The resulting DOA estimates from such a realizable system could contain large spikes or "glitches" at these points. These encoding errors in the resolved DOA can be reduced by interpolation. Three primary methods will be discussed to compare the capability of removing the glitches: LSB-Shift Method, Random-LSB Method, and Shift Last Good-Sample Method. A comparison of the performance of the three methods is made on the basis of simulation data.

IDENTIFICATION OF PUSH-TO-TALK TRANSMITTERS USING WAVELETS
Yalcin Payal-Lieutenant Junior Grade, Turkish Navy
B.S., Turkish Naval Academy, 1989
Master of Science in Electrical Engineering-December 1995
Advisors: Ralph Hippenstiel, Department of Electrical and Computer Engineering
Monique P. Fargues, Department of Electrical and Computer Engineering

The main objective of this study is to find a wavelet-based, feature extracting algorithm for push-to-talk transmitter identification. A distance-measure algorithm is introduced to classify signals belonging to one of four transmitters. The signals are first preprocessed to put them into a form suitable for wavelet analysis. The preprocessing scheme includes taking envelopes and differentials. Median filtering is applied to the envelopes and the differentials to denoise the data. The preprocessed data takes on a pulse-like shape, which is suitable for wavelet processing. The distance algorithm is applied to the outputs (scales) of the wavelet transform. The distance algorithm uses local extrema of the wavelet

coefficients, and computes the distance between the local extrema of a template and the processed signals. A small distance implies high similarity. A signal from each transmitter is selected as a template. The distance measure is computed between any signal of interest and the reference templates. The signals are identified to belong to one of four transmitters according to the distance measure. A small distance measure indicates that the signal belongs to the transmitter from which the template originated. The distance algorithm can classify correctly the four different signal sets provided for the research and, even at lower signal-to-noise levels, good identification is achieved.

THE PROBABILITY OF DETECTION OF CERTAIN THREAT EMITTERS USING MULTIPLE COLLECTION SOURCES

Stephen Christopher Pearson-Lieutenant, United States Navy
B.S.E.E., Virginia Military Institute, 1988
Master of Science in Electrical Engineering-June 1996
Advisors: George H. Lowe III, Field Station USJ-751
Vicente C. Garcia, Department of Electrical and Computer Engineering

It has long been the practice of the military and national personnel to inform the warfighter when a threat emitter has been detected in their area of operations to ensure their safety. With the United States military being called upon by the President to take part in numerous Peace Keeping, Humanitarian Aid, Crisis Intervention and Military Operations, it is critical that military forces are given as much warning as possible that impending hostile acts might occur. It is therefore the purpose of this thesis to determine how well our various collection sources can detect threat emitters. In this thesis, the probability of detection of certain threat emitters using multiple collection sources is evaluated.

MULTIRESOLUTION IMAGE RECOGNITION USING THE WAVELET TRANSFORM

William M. Peyton, Jr.-Lieutenant, United States Navy
B.S., University of Pennsylvania, 1988
Master of Science in Electrical Engineering-June 1996
Electrical Engineer Degree-June 1966
Advisor: Murali Tummala, Department of Electrical and Computer Engineering
Second Reader: Ralph Hippenstiel, Department of Electrical and Computer Engineering

With the growth of information dissemination over digital communication networks, much research has been devoted to compressing digital image information for efficient transmission. The ability to adjust the desired resolution of an image as the available bandwidth on the network changes allows the user to control the flow of data according to the resources available. In this thesis we integrate multiresolution image compression methods with image recognition. Features of grayscale and binary images of text characters and aircraft line drawings are described using wavelet transform coefficients, wavelet transform subband energy, and Fourier transform coefficients. Transmission of these features over a digital communication link is simulated, and multiresolution recognition performance in the presence of channel noise is presented.

RANGE-DEPENDENT PASSIVE SOURCE LOCALIZATION USING DATA FROM THE BARENTS SEA TOMOGRAPHY EXPERIMENT

David D. Pierce-Lieutenant Commander, United States Navy
B.S., University of Rochester, 1983
M.S., Naval Postgraduate School, 1989
Doctor of Philosophy in Engineering Acoustics-June 1996
Advisor: Charles Therrien, Department of Electrical and Computer Engineering

Matched Field Processing (MFP) and Matched-Mode Processing (MMP) are two popular techniques for passively localizing an underwater acoustic emitter in range and depth. One major drawback of these techniques has been their

sensitivity to uncertainty concerning the acoustic environment. Several methods for addressing this phenomenon have been proposed in the literature, with varying degrees of success. Achieving high-quality location estimates remains a problem except in simple range-independent experiments or numerical simulations. In this study, we demonstrate an approach for robust, accurate emitter localization in a highly range dependent real environment using MMP. The main factors contributing to successful localization are: 1) use of the high-resolution Multiple Signal Classification (MU-SIC) algorithm, which performs well even when only a few robust modes can be obtained by mode filtering, and 2) use of an acoustic propagation model incorporating mode coupling, which is able to generate accurate replica fields in a strongly range-dependent environment. A secondary objective of the study was to demonstrate the application of higher-order statistical estimation techniques to reduce noise effects. Our results indicate that these techniques show unacceptable sensitivity to noise- and model-induced estimation errors and require further refinement before they will be useful in the underwater acoustic localization problem.

A PROGRAMMABLE OFFSET DIFFERENTIAL ECL FOUR CHANNEL CLOCK GENERATOR FOR APPLICATIONS IN HIGH RESOLUTION DIGITAL ANTENNAS

Alan P. Pietruszewski-Lieutenant Commander, United States Navy
B.A., Canisius College, Buffalo N.Y., 1984
Master of Science in Electrical Engineering-September 1996
Advisor: Phillip E. Pace, Department of Electrical and Computer Engineering
Second Reader: Ronald J. Pieper, Department of Electrical and Computer Engineering

Digital antennas are being developed today that will operate directly at radio frequencies (RF), thus eliminating the need for intermediate and broadband processing. Promising techniques include the use of optical processors integrated with digital technology to provide the speed and bandwidth necessary for this capability. High resolution optical processors utilize a small parallel array of high-bandwidth interferometers to preprocess the RF signal at the antenna. This work documents the design and construction of a 4-channel programmable offset differential ECL clock generator. The clock generator is used in a symmetrical number system 14-bit digital antenna currently under construction in the Optical Electronics Laboratory at the Naval Postgraduate School. Circuit concepts are detailed along with experimental results of the final design. Results show that the 30 ns wide clock signal generated can be accurately positioned in time to facilitate proper latching of the GaAs comparator arrays. Noise levels within each stage of the clock generator are also quantified. The design is researched, assembled and tested in a wire wrap version.

SIMULINK MODELLING OF A MARINE AUTOPILOT FOR TSSE SHIP DESIGNS

Christopher A. Poor-Lieutenant, United States Navy
B.S., Maine Maritime Academy, 1988
Master of Science in Electrical Engineering-September 1996
Advisor: R.G. Hutchins, Department of Electrical and Computer Engineering
Second Reader: H. Titus, Department of Electrical and Computer Engineering

This thesis covers the design, simulation and analysis of a SIMULINK system designed to predict the maneuvering characteristics of the Total Ship System Engineering (TSSE) program's first proposed hull design. The system is developed in three degrees of freeom. The ship's hydrodynamic derivatives are predicted in MATLAB code, while the engine is modeled completely in a SIMULINK environment.

To test the system's applicability, an underway replenishment scenario is used to simultaneously test the steering and engine control subsystems.

Two controllers are employed in the system. The first is used to drive the ship in a fashion similar to that of a human conning officer during an underway replenishment. The other is a root locus design used to improve the engine's response.

A STUDY OF UHF FLTSATCOM VULNERABILITIES AND ITS APPLICATION
TO CLASSIC CRYSTAL

Eugene P. Potente-Lieutenant Commander, United States Navy
B.S., United States Naval Academy, 1986
Master of Science in System Engineering-September 1996
Advisor: Vicente Garcia, Department of Electrical and Computer Engineering
Second Reader: D. C. Schleher, Information Warfare Academic Group

Determine the minimum satellite transponder uplink frequency separation for satellites having overlapping field-of-views for the world-wide UHF FLTSATCOM system (LEASAT/GAPFILLER/FLTSAT/UFO) for the current satellite orbit configuration/ transponder frequency plan. Examine the vulnerability of the SSIXS users given the current UHF satellite system configuration/frequency plan and see if a more intelligent choice of channel/frequency plan could reduce the vulnerability of SSIXS DAMA users.

PARAMETRIC (EWIR) DIFFERENCES IN HIL MISSILE
SIMULATORS: IMPACT ON ELECTRONIC ATTACK SYSTEMS

Larry Alan Pugh-Lieutenant Commander, United States Navy
B.S., Southern Methodist University, 1983
Master of Science in Aeronautical Engineering-December 1995
Advisor: Phillip E. Pace, Department of Electrical and Computer Engineering

Failure to accurately simulate threat radar missile systems, in particular Anti-Ship Cruise Missiles, can have enormous ramifications in the training and evaluation of both personnel and electronic warfare equipment. In light of the current fiscal environment where defense dollars are extremely limited, a single generic simulator must be designed to represent several threat radar missile systems. This simulator must operate with a high degree of fidelity in order to provide an accurate and meaningful evaluation of the effectiveness of shipboard electronic attack systems designed to defeat these threat missile systems. This work examines the effect that parametric differences between the threat simulator and actual threat weapon systems will have on the operation of a variety of the most commonly used active electronic attack techniques. Specifically, does an error in the parameter influence how a particular technique is designed to function, and if so, in what manner is the technique affected by the parameter. The parameters of interest that are examined are taken from the Electronic Warfare Integrated Reprogramming database parameters.

A REAL-TIME IMAGE UNDERSTANDING SYSTEM FOR AN AUTONOMOUS ROBOT

Leonard V. Remias-Lieutenant, United States Navy
B.S., Old Dominion University, 1987
Master of Science in Computer Science-March 1996
Advisors: Yutaka Kanayama, Department of Computer Science
Chin-Hwa Lee, Department of Electrical and Computer Engineering

Yamabico-11 is an autonomous mobile robot used as a research platform with one area in image understanding. Previous work focused on edge detection analysis on a Silicon Graphics Iris (SGI) workstation with no method for implementation on the robot. *Yamabico*-11 does not have an on-board image processing capability to detect straight edges in a grayscale image and a method for allowing the user to analyze the data.

The approach taken for system development is partly based on edge extraction and line fitting algorithms of [PET92] with a 3-D geometric model of the robot's world [STE92]. Image grabbing routines of [KIS95] were used to capture images with the robot's digital output camera and processed using image understanding routines developed for a SGI workstation. The routines were modified and ported onto the robot.

The new method of edge extraction produces less ambient noise and more continuous vertical line segments in the gradient image which enhances pattern matching analysis of the image. *Yamabico*-11.'s computer system can capture

an image with a resolution of 739 x 484 active picture elements. Edge detection analysis is performed on the robot which generates a list structure of edges and stored in the robot's memory for user analysis.

THE DESIGN OF A PREDICTIVE READ CACHE
Joseph R. Robert, Jr.-Lieutenant, United States Navy
B.S., State University of New York at Buffalo, 1988
Master of Science in Electrical Engineering-March 1996
Advisor: Douglas J. Fouts, Department of Electrical and Computer Engineering
Second Reader: Frederick W. Terman, Department of Electrical and Computer Engineering

The objective of this research has been the creation of a hardware design for a Predictive Read Cache (PRC). The PRC is a developmental cache intended to replace second-level caches common in modern microprocessor systems. The PRC has the potential of being faster and cheaper than current second-level caches and is distinctive in its ability to predict data addresses to be referenced by a central processing unit.

Previous research has analyzed the behavior that the PRC must exhibit. During the described research, the behavior was modeled in the Verilog hardware description language. Verilog-XL was used for simulation, which uses the Verilog behavioral model as input. The behavioral model suggests that the internal structure of the PRC could be divided into six modules, each performing part of the function of the whole PRC. Each of these blocks was studied for hardware equivalents, easing the development of the total structural model.

Using Verilog structural models as input, Epoch was used to automatically perform a very large-scale integrated (VLSI) circuit layout and to generate timing information. The Epoch output files are used for further simulation with Verilog-XL to identify critical parts of the design. The result of this research is a complete hardware design for the PRC.

TIMELY AND RELEVANT IW/C²W MODELING
Timothy G. Rohrer-Lieutenant, United States Navy
B.S., Oregon State University, 1988
Master of Science in Systems Engineering-September 1996
Advisors: Fred Levien, Information Warfare Academic Group
Vicente Garcia, Department of Electrical and Computer Engineering

Today's environment is characterized by rapid technological change in communication systems and networks. These rapid changes make the task of developing timely and useful C^2W and C^2W support systems difficult at best. This thesis provides discussion on whether commercial-off-the-shelf programs, combined with government-off-the-shelf models, can create solutions to the IW/C^2W challenge. We worked with a modeling and simulation program, GLEEM, developed by the AFIWC to analyze GPS links in an hostile jamming environment. Here, GLEEM is considered a starting point for a generic modeling program to be used for detailed analysis of C^2W related network links. We chose GLEEM because it includes features not completely included in other projects, thus providing a greater capability to model real world IW scenarios and questions posed by commanders. Two means of providing insight on GLEEM are used. First, we use GLEEM to simulate a modern mobile communication link and the ability of a space-based receiver to detect the signal. Second, we use the information we've learned about GLEEM to discuss how it might be used to simulate current research at NPS. We conclude that programs like GLEEM are in their infancy but there is significant potential and development work should continue.

RECENT ADVANCES IN THE TECHNOLOGY OF MICROWAVE DEVICES EMPLOYED IN RADAR SYSTEMS, AND THE IMPACT OF THESE TECHNOLOGIES ON POTENTIAL IMPROVEMENTS TO RADAR SYSTEM PERFORMANCE

Emmanouil Sakiotis-Lieutenant, Hellenic Navy
B.S., Hellenic Navy Academy, 1987
Master of Science in Electrical Engineering-June 1996
Advisor: Fred Levien, Department of Electrical and Computer Engineering
Second Reader: Sherif Michael, Department of Electrical and Computer Engineering

This thesis is a study of the recent advances in microwave device technology that can be applied to the improvement of phased array radar systems which are able to provide multifunction capabilities to navy ships. The study was undertaken to provide guidance to military planners who are often required to keep abreast of developments in a rapidly changing field of technology. The fact that even the most advanced presently-used radar systems in the navy are based on five to ten year-old technology verifies the need for this study.

Microwave Power Modules which combine vacuum tube and Solid State technology have been developed and have demonstrated advanced performance characteristics. Their advantages, such as very wide bandwidth and ability to operated at much higher ambient temperatures than those of the Solid State devices have opened up new opportunities for their use in Radar systems. However, output power capability of MPM, while growing rapidly, is still below the minimum level required for a phased array radar on board a midsize ship operating in confined waters.

The present technology available however in Solid State Transmit/Receive modules, does supply the capabilities needed for a realization of all active phased array radar. Such a system will enhance ships operational capabilities while achieving a reduction of the prime power consumption as well as in needed space. The applicability and characteristics of these devices are presented in this thesis.

CONTROLLER DESIGN, ANALYSIS, AND PROTOTYPE FOR SHIP SERVICE CONVERTER MODULE

Benjamin D. Salerno-Lieutenant, United States Navy
B.S.E.E., United States Naval Academy, 1989
Master of Science in Electrical Engineering-June 1996
Advisor: Robert W. Ashton, Department of Electrical and Computer Engineering
Second Reader: John G. Ciezki, Department of Electrical and Computer Engineering

The Navy has invested in an effort to update the ship electrical distribution system for new vessels. The new architecture divides the ship into specific zones containing common energy conversion devices. Rather than the traditional AC distribution, DC will be produced at the source (a multiphase alternator connected to a controlled rectifier). An integral part of the proposed DC distribution system is the Ship Service Converter Module (SSCM) which acts as a buffer between a main DC bus and a specific zone in the ship. Currently a research effort is underway to make available two Reduced Scale Advanced Development (RSAD) 100kW SSCMs for testing at the Naval Surface Warfare Center, Annapolis. The Power Laboratory at the Naval Postgraduate School is responsible for delivering two identical prototype controllers based on digital signal processors for the RSAD SSCMs. The focus of this thesis is the design, construction and testing of the prototype controllers. This engineering effort includes the following: the analysis of the performance of various control algorithms through simulation; the refinement of the selected algorithm; the design, assembly, and testing of the controller and its supporting hardware; the development and testing of the software; and the integration and testing of the complete system.

BISTATIC RADAR CROSS SECTION SYNTHESIS FOR RECTANGULAR RESISTIVE SHEETS

Ugurcan Samli-Lieutenant Junior Grade, Turkish Navy,
B.S., Turkish Naval Academy, 1990
Master of Science in Systems Engineering-September 1996
Advisor: David C. Jenn, Department of Electrical and Computer Engineering
Second Reader: D. Curtis Schleher, Information Warfare Academic Group

A method of moments solution for the bistatic scattering from planar resistive sheets is presented. The matrix scattering equations are inverted to obtain a rigorous inverse solution that can be applied to the synthesis of radar cross section. Computer calculations for several sheets demonstrate that the synthesized resistivity is in good agreement with the original resistivity.

ENHANCED VISUALIZATION METHODS FOR CHANNEL EFFECTS IN THE RADIO FREQUENCY MISSION PLANNER

Jeffrey Scott Scheidt-Lieutenant, United States Navy
B.S.E., University of Michigan, 1990
Master of Science in Electrical Engineering-December 1995
Advisor: Gus K. Lott, Department of Electrical and Computer Engineering

This thesis presents the design of visualization enhancements for the Radio Frequency Mission Planner. The RFMP uses radio frequency propagation models to predict and analyze electromagnetic behavior within a terrestrial environment described by a system operator. The core of RFMP is a set of six propagation models employing different modeling methods and producing output with varying degrees of accuracy. Enhancements to RFMP visualization require the display of the stochastic characteristics of model output. Detailed study of the PROPHET and TIREM propagation models within RFMP, along with the RFMP system architecture, produced visualization enhancements capable of displaying model stochastic behavior regardless of errors or distribution type. Proposed improvements build upon LOTT PLOT calculations and standard model output to extend system visualization power by measuring confidence in computed field values. These enhancements aide the user in identifying planning shortfalls and accelerating plan revisions.

THE DISADVANTAGE OF DIGITAL TECHNOLOGY

Richard E. Scott-Lieutenant, United States Navy
B.S., United States Naval Academy, 1988
Master of Science in Systems Technology (Space Systems Operations)-September 1996
Advisor: Herschel H. Loomis, Department of Electrical and Computer Engineering
Vicente C. Garcia, Department of Electrical and Computer Engineering

Digital communications have been growing in popularity since the early 1970s. They offer many advantages over analog technology including improved signal quality, efficiency, interoperability, and lower cost. With this increase in popularity, the United States Intelligence Community is faced with a challenge. Collection against digital signals of interest is more difficult than that of their analog counterparts.

These challenges can be separated into three broad categories: scenario geometry, signal processing and limitations of current receiver capabilities. Scenario geometry refers to target access. Many signals are difficult to exploit simply because it is difficult to put collection assets in a position that permits access. The next challenge is processing. By its nature, digital signal processing is more complex and asset intensive than analog. Finally, any exploitation equipment has physical limitations. As targets gain more advanced technology, the limits of intercept equipment will be exceeded. New equipment will always be needed to match the growing threat. This paper discusses these difficulties in detail and makes recommendations for improved asset utilization and acquisition of future assets.

IMPROVEMENTS IN THE THREAT SIMULATOR MODEL DEVELOPMENT ENVIRONMENT
Kellog Cole Sharp-Lieutenant, United States Navy
B.S., United States Naval Academy
Master of Science in Electrical Engineering-September 1996
Advisor: Phillip E. Pace, Department of Electrical and Computer Engineering
Second Reader: Frederic H. Levien, Department of Electrical and Computer Engineering

Currently there are a limited number of tools available for quantifying the effectiveness of a shipboard anti-shipping missile electronic attack waveform. The *P-3 Captive-Carry Correlation* algorithms, which include the *Threat Simulator Model Environment* and the necessary preprocessing for open-loop field tests, represent a unique approach to numerically evaluating electronic attack effectiveness. This thesis addresses modifications to the *Threat Simulator Model Environment*, tuned using hardware-in-loop threat simulator (closed-loop) data obtained from the Central Targeting Simulator anechoic chamber. The *Threat Simulator Model Environment* plays a significant role in calculating a miss distance from P-3 captive-carry open-loop field test results. The closed-loop results originally used to tune the model were taken with a sampling rate of 1 Hz and provided encouraging results. This thesis documents several modifications to the *Threat Simulator Model Development Environment* and the incorporation of closed-loop (Central Targeting Simulator Facility) results generated using a 50 Hz sampling rate. The modifications and the use of higher bandwidth data (50 Hz) significantly improves the correlation between the model results and the threat simulator performance in the anechoic chamber.

PERFORMANCE ANALYSIS OF MILSTAR LOW DATA RATE DOWNLINK
Patrick W. Smith-Lieutenant, United States Navy
B.S.M.E., University of Arizona, 1988
Master of Science in Electrical Engineering-September 1996
Advisor: R. Clark Robertson, Department of Electrical and Computer Engineering
Second Reader: Paul H. Moose, Department of Electrical and Computer Engineering

In this thesis a model of the Milstar communication satellite downlink is developed for two modulation techniques and an error analysis is performed for both. The first signaling technique investigated is M-ary frequency-shift keying (MFSK) where the system is evaluated for a partial-band jamming environment. An analysis with worst case partial-band noise jamming is performed and performance as a function of the energy per bit-to-jammer power spectral density ratio is plotted for Milstar's various MFSK modes. Also considered is the signal power-to-jammer power ratio for the various modes. The second signaling technique investigated is differential phase-shift keying (DPSK). A similar error analysis is performed for the DPSK signal, and the performance as a function of the energy per bit-to-jammer power spectral density ratio and signal power-to-jammer ratio are plotted. For both modulation formats, all plots are obtained for a constant bit error rate of 10^{-5} and for four different thermal noise levels. Technical descriptions of the capabilities and functions of the Milstar satellite system including signal processing, frequency plan, and waveform design are also included.

ANALYSIS OF HARDWARE IMPLEMENTATION AND SPEED CONTROL OF A SLIP ENERGY RECOVERY SYSTEM
Brian S. Tait-Lieutenant, United States Navy
B.S., United States Naval Academy, 1989
Master of Science in Electrical Engineering-December 1995
Advisor: John G. Ciezki, Department of Electrical and Computer Engineering

This thesis involves the construction and testing of a Slip Energy Recovery System (SERS). The principal component of the SERS is a wound rotor induction machine which allows for extraction of slip power from the rotor which in turn provides a means of speed control. Induction machines normally operate at a constant speed, but SERS offers a method of speed control which increases efficiency by returning the slip power back to the system.

In this research effort, various tests required to analyze speed range, signal waveforms and power flow were conducted. Additionally, an analog and a microprocessor-based control scheme were implemented for speed control. A number of studies are presented to validate and contrast the proposed circuits.

The system data collected during validation studies are compared against the theoretical operation of the SERS. After construction, alternative topologies are investigated in order to assess the configuration that provides an optimal speed range. A baseline was established and it is shown that the location of the transformer in the SERS has a significant influence on the speed range.

Results from further testing of the baseline configuration revealed that in regards to waveforms and power flow, the system responded as expected.

MOTION PLANNING AND DYNAMIC CONTROL OF THE NOMAD 200 MOBILE ROBOT IN A LABORATORY ENVIRONMENT

Ko-Cheng Tan-Lieutenant Commander, Republic of China Navy
B.S., Chinese Naval Academy, 1984
Master of Science in Aeronautical Engineering-June 1996
Advisor: Xiaoping Yun, Department of Electrical and Computer Engineering
Second Reader: Isaac Kaminer, Department of Aeronautics and Astronautics

Motion planning and control of a Nomad 200 mobile robot are studied in this thesis. The objective is to develop a motion planning and control algorithm that is able to move the robot from an initial configuration (position and orientation) to a goal configuration in a typical laboratory environment. The robot must be able to avoid unknown static (e.g., walls and tables) and dynamic (e.g., people) obstacles. Dubin's algorithm finds the shortest path connecting two configurations in an obstacle-free environment, but it is not able to avoid obstacles present in the environment. The potential field algorithm is effective in avoiding unknown obstacles, but it has the local minimum problem and does not consider the orientation of a mobile robot. A modified potential field algorithm is first developed. The algorithm overcomes local minima in a typical laboratory environment. The modified potential field algorithm is then combined with Dubin's algorithm to incorporate orientation into motion planning. The combined algorithm is able to avoid static and dynamic obstacles and achieve position and orientation requirements. Simulation and physical experiment results are presented to demonstrate the effectiveness of the algorithm.

EFFECTIVENESS OF OFF-BOARD ACTIVE DECOYS AGAINST ANTI-SHIPPING MISSILES

Tun-Hou Tan-Lieutenant Commander, Republic of China Navy
B.S., Republic of China Naval Academy, 1986
Master of Science in Systems Engineering-September 1996
Advisors: D. Curtis Schleher, Information Warfare Academic Group
David Jenn, Department of Electrical and Computer Engineering

Radar guided anti-shipping missiles are the primary threat for most modern Navies. The inherent nature of the monopulse radar employed by most anti-shipping missiles makes it highly resistant to active ECM techniques. Decoys are attractive because they provide a source of radiation that can capture the radar seeker and direct the missile away from the ship. However the time and direction of launch are critical parameters which determine the operational success of the decoy.

This thesis evaluates the protection provided by active off-board decoys which are deployed by ships during an engagement against a radar guided anti-shipping missile. The research emphasizes launching active decoys. Many of the operational characteristics of the launching decoy are investigated, including direction of launch, timing of launch and the RF characteristics of the decoy.

PERFORMANCE OF FFH/BFSK SYSTEMS WITH CONVOLUTIONAL CODING AND SOFT DECISION VITERBI DECODING OVER RICIAN FADING CHANNELS WITH PARTIAL-BAND NOISE INTERFERENCE

Michael D. Theodoss-Captain, United States Army
B.S.E.E., University of Massachusetts at Amherst, 1987
Master of Science in Electrical Engineering-December 1995
Advisor: R. Clark Robertson, Department of Electrical and Computer Engineering
Second Reader: Ralph Hippenstiel, Department of Electrical and Computer Engineering

An error probability of analysis of a communications link employing convolutional coding with soft decision Viterbi decoding implemented on a fast frequency-hopped, binary frequency-shift keying (FFH/BFSK) spread spectrum system is performed. The signal is transmitted through a Rician fading channel with partial-band noise interference. The receiver structures examined are the conventional receiver with no diversity, the conventional receiver with diversity and the assumption of perfect side information, and the self-normalized combining receiver with diversity. The self-normalized receiver minimizes the effects of hostile partial-band intereference, while diversity alleviates the effects of fading. It is found that with the implementation of soft decision Viterbi decoding that the performance of the self-normalized receiver is improved dramatically for moderate coded bit energy to partial-band noise power spectral density ratio (E_b/N_l). Coding drives the jammer to a full band jamming strategy for worst case performance. Nearly worst case jamming occurs when barrage jamming is employed and there is no diversity even in cases where there is very strong direct signal. Performance improves as the constraint length of the convolutional code is increased. Performance is seen to degrade slightly with increasing diversity except in instances of a very weak direct signal. Also, soft decision decoding is found to be superior to hard decision decoding by approximately 4 dB at moderate E_b/N_l.

PERFORMANCE OF A COMMUNICATIONS SYSTEM WHEN SUBJECTED TO THE PGS 402 ULTRA-WIDE-BAND IMPULSE GENERATOR

David Mitchell Thomas-Captain, United States Army
B.S., University of Kentucky, 1981
Master of Science in Electrical Engineering-September 1996
Advisor: R. Clark Robertson, Department of Electrical and Computer Engineering

This thesis is an investigation of the performance of a communications system when subjected to the PGS 402 ultra-wide-band (UWB) impulse generator. Also investigated is the shape of the pulse at different points in the receive path of the receiver.

Measurements were taken at an Electromagnetic Interference Test Facility. Bit error rate measures were taken for a fixed pulse repetition frequency (PRF) of 5 kHz for varying signal power-to-jamming power ratios (S/J) and for fixed S/J with varying PRF. The shape of the pulse was measured both when the pulse was transmitted and when the pulse was directly injected into the receiver, bypassing the antenna. Measurements for both the transmitted pulse and the directly injected pulse were recorded in the time domain at the output of the Impedance Matching Unit, Exciter/Power Amplifier, Voltage Control Oscillator, Tuner/Mixer, and Demodulator.

Lastly, a determination was made of the maximum effective distance of the jammer from the receiver and the effective isotropic radiated power (EIRP) of the jammer required to render the receiver unreliable.

ANALYSIS, SIMULATION AND DESIGN OF THE MAPHAM CONVERTER

Jerry D. Tyner-Lieutenant, United States Navy
B.S., United States Naval Academy, 1987
Master of Science in Electrical Engineering-December 1995
Advisors: John Ciezki, Department of Electrical and Computer Engineering
Robert Ashton, Department of Electrical and Computer Engineering

In the mid to late sixties, Dr. Neville Mapham worked extensively as an application engineer in the Semiconductor Products Department of the General Electric Company, where he specialized in inverters and the high-frequency operation of silicon controlled rectifiers. His success in the power electronics field produced three equivalent parallel output resonant converter configurations, the center-tapped supply, the bridge, and the center-tapped load. To further expand on Dr. Mapham's work, this thesis analyzes, simulates, and designs the center-tapped supply and bridge topologies. Simulation of both configurations is conducted utilizing PSpice software. In addition, the center-tapped supply converter is constructed and studied in the Power Systems Laboratory. For design purposes, a specific listing of hardware components is given. Series connection through a transformer of the Mapham bridge is investigated and implementation issues are addressed.

A WIDE ANGLE SPLIT-STEP PARABOLIC EQUATION MODEL FOR PROPAGATION PREDICTIONS OVER TERRAIN

Konstantinos Vlachos-Hellenic Navy
B.S.E.E., Hellenic Naval Academy, June 1988
Master of Science in Electrical Engineering-March 1996
Advisor: Ramakrishna Janaswamy, Department of Electrical and Computer Engineering

The problem of radiowave propagation over irregular terrain is solved by using the wide angle parabolic equation method. The terrain is characterized by its height profile and its ground constants (here conductivity s Æ∞). We consider horizontal polarization and treat the ground as perfectly conducting (PEC) to simplify the formulation. This thesis uses a piecewise conformal transformation to flatten the irregular terrain. The equations are solved by the split-step Fourier algorithm. A Hanning window is used both in spatial and in wavenumber domains to contain the computational domain. Effect of some numerical parameters such as the horizontal step size, height of computational domain on the accuracy of the solution is investigated. The numerical results are compared with available results for some typical propagation problems.

A HIERARCHICAL APPROACH TO MULTICAST IN A DATAGRAM INTERNETWORK

Robert J. Voigt-Commander, United States Navy
B.S., United States Naval Academy, 1979
M.S., Naval Postgraduate School, 1986
Doctor of Philosophy in Electrical Engineering-March 1996
Advisor: Shridhar Shukla, Department of Electrical and Computer Engineering

Multicasting in datagram internetworks enables multi-party interactions among users distributed over wide areas by eliminating duplicate packets in one-to-many and many-to-many communication. It requires formation of a tree to distribute multicast data to the communicating group of members.

Present multicast techniques need improvement in scope control, resource discovery mechanisms, and tree construction to efficiently support a large number of global groups with dense as well as sparse membership. We deploy a hierarchy of clustered routers with the following features to make these improvements. Each group is assigned a *scope level* enabling access to resources at that level when members join and permits well-defined boundaries for scope control. The list of border routers and presence of groups at any level is maintained and supplied to members by a level-specific resource discovery mechanism called a *registrar*. To make tree construction scaleable, the border routers determine the shortest inter-cluster paths to source clusters using the available unicast routing information, facilitating

aggregation of router state for all senders in a cluster. Unlike the existing approaches, administrative configuration of the hierarchy eliminates the need for locating distribution centers dynamically.

We characterize the path length performance of the proposed hierarchy by providing an upper bound for the penalty as compared to source-specific trees. Simulation results for randomly generated topologies verify the worst case penalty and show the actual penalty to be significantly less. These results show that the proposed hierarchy can be deployed over the existing unicast routing infrastructure to achieve scaleable multicasting with the required scope control while keeping the path length penalty bounded. The architecture described permits further improvements in the path length penalty if the identified enhancements to the underlying unicast routing mechanisms are made.

DESIGN AND EVALUATION OF AN INTEGRATED, SELF-CONTAINED GPS/INS SHALLOW-WATER AUV NAVIGATION SYSTEM (SANS)

Randy G. Walker-Captain, United States Marine Corps
B.S.E.E., San Diego State University, 1990
Master of Science in Electrical Engineering-June 1996
Master of Science in Computer Science-June 1996
Advisors: Xiaoping Yun, Department of Electrical and Computer Engineering
Robert B. McGhee, Department of Computer Science
Second Reader: Eric R. Bachmann, Department of Computer Science

The main problem addressed by this research is to find an alternative to the use of large and/or expensive equipment required by conventional navigation systems to accurately determine the position of an Autonomous Underwater Vehicle (AUV) during all phases of an underwater search or mapping mission.

The approach taken was to advance an existing integrated navigation system prototype which combines Global Positioning System (GPS), Inertial Measurement Unit (IMU), water speed, and heading information using Kalman filtering techniques. The hardware and software architecture of the prototype system were advanced to a level such that it is completely self-contained in a relatively small, lightweight package capable of on-board processing of sensor data and outputting updated position fixes at a rate of 10 Hz; an improvement from the 5 Hz rate delivered by the prototype. The major changes to the preceding prototype implemented by this research were to install an on-board processor to locally process sensor outputs, and improve upon the analog filter and voltage regulation circuitry.

Preliminary test results indicate the newly designed SANS provides a 100% performance improvement over the previous prototype. It now delivers a 10 Hz update rate, and increased accuracy due to the improved analog filter and the higher sampling rate provided by the processor.

A COMPARISON OF DDS AND DRFM TECHNIQUES IN THE GENERATION OF "SMART NOISE" JAMMING WAVEFORMS

Charles Joffery Watson-Captain, United States Army
B.S., University of Pittsburgh, 1988
Master of Science in Systems Engineering-September 1996
Advisors: Phillip E. Pace, Department of Electrical and Computer Engineering
D. Curtis Schleher, Information Warfare Academic Group

This thesis presents a comparison of the effectiveness of "smart noise" jamming waveforms against advanced threat radars, which are generated using either Direct Digital Synthesis (DDS) or Digital RF Memory (DRFM) based support jamming. The challenge lies in the fact the modern radar employs advanced waveforms, ultra-low sidelobe antennas, coherent sidelobe cancelers, and sidelobe blankers to inhibit signals entering through its sidelobes. This thesis compares the effectiveness of using DDS versus DRFM techniques to meet this challenge. In particular, the effect of mismatched frequency on the DDS jamming waveform is described, as is the effect of quantization and multi-signal storage in the DRFM. A quantitative comparison of these jamming techniques against the AN/TPS-70 surveillance radar is made.

NPS HIGH RESOLUTION SYNTHETIC APERTURE SONAR

Joseph Donald Welter-Lieutenant Commander, United States Navy
B.S.E.E., United States Naval Academy, 1982
Master of Science in Electrical Engineering-December 1995
Master of Science in Applied Physics-December 1995
Advisors: Donald Walters, Department of Physics
Roberto Cristi, Department of Electrical and Computer Engineering

This thesis investigated the use of synthetic aperture techniques to achieve a long effective aperture, high resolution, imaging sonar. The approach included a full simulation of the system using the MATLAB programming environment that provided a model for developing six data processing algorithms and a working 25KHz, 1 m baseline, air medium synthetic aperture sonar. The six azimuthal processing techniques included: 1) a normal, real aperture, 2) an unfocused synthetic aperture, 3) a hybrid focused-unfocused system, 4) a fully focused one line algorithm, 5) a limited two-dimensional, fully focused algorithm and, 6) a limited two-dimensional, hybrid focused-unfocused algorithm. This thesis compared the run times, resolutions, and signal to noise ratios achieved by the six techniques both in simulation and experimental measurements collected with the actual prototype.

IMPLEMENTATION AND EVALUATION OF COMMERCIAL OFF-THE-SHELF (COTS) VOICE RECOGNITION SOFTWARE AS AN INPUT DEVICE IN A WINDOWS-TYPE ENVIRONMENT

Timothy J. West-Lieutenant, United States Navy
B.A., Virginia Military Institute, 1988
Master of Science in Information Technology Management-March 1996
Advisor: Monique P. Fargues, Department of Electrical and Computer Engineering

This thesis investigates the implementation and evaluation of commercial off-the-shelf (COTS) voice recognition as an input interface within a windows-type environment. The three software packages implemented and evaluated are DragonDictate For Windows, version 1.3, VoicePilot 2.0 (both manufactured by Dragon Systems, Inc.) and IN³ Voice Command for SPARCstation version 2.2.2 by Command Corp. VoicePilot and DragonDictate are both installed on PCs running MS Windows 3.1, and IN³ is installed on a SPARCstation running OpenWindows 3 and SunOS 4.1.3. Several applications are manipulated using voice recognition with these three software packages. The results of this study show that DragonDictate has the most flexibility and ease of use as an input device for a windows-type environment. It is also shown that as usage increases, DragonDictates recognition accuracy is able to be improved to above 98%. Other areas of future research are also suggested.

VULNERABILITY OF INTELSAT/VSAT SYSTEMS

Kevin M. Wilson-Lieutenant Commander, United States Navy
B.S., University of Houston, 1985
Master of Science in Astronautical Engineering-June 1996
Advisor: Vicente Garcia, Department of Electrical and Computer Engineering
Second Reader: Sandra Scrivener, Department of Aeronautics and Astronautics

This thesis considers the Navy's use of the International Telecommunications Satellite (INTELSAT) system with emphasis on the future utilization of Ku-band Super High Frequency (SHF) communications in the Navy's satellite communications architecture. In particular, it evaluates the use of very small aperture terminal (VSAT) networks in conjunction with the INTELSAT system. The scenario examined will be an hypothetical contingency operation with the U.S. Navy supporting a joint special operations force (JSOF) in a coastal region by providing communications, command, control and intelligence support using an INTELSAT/VSAT system.

The increased and mandated use of commercial satellite technology leads to a whole new arena of potential risks to exploitation. Critical vulnerability issues such as detection and interception, and anti-jamming will be addressed. This

thesis is designed to aid the communications planner in his/her efforts to support the satellite communications requirements of the military end-user.

ERROR PROBABILITIES OF SPREAD SPECTRUM SYSTEMS
IN AN ULTRA WIDEBAND SOURCE (UWBS) INTERFERENCE
Eng-Kiong Yeu-Defense Technology Group, Singapore
B. Eng., National University of Singapore, 1991
Master of Science in Electrical Engineering-September 1996
Advisors: Tri T. Ha, Department of Electrical and Computer Engineering
Vicente Garcia, Department of Electrical and Computer Engineering

This thesis investigates the potential jamming capabilities of an ultra wideband source (UWBS) jammer on the direct sequence (DS) and frequency hopping (FH) spread spectrum systems using the Advanced Communication Link Analysis and Design (ACOLADE) tool. Error probabilities in both the additive white Gaussian noise channel and the Rayleigh fading channel are obtained with and without convolutional coding. Comparison is made to examine whether an UWBS jamming is more effective on the DS or FH systems given the same jammer power. The thesis also presents how several jammer parameters could be varied in order to inflict more harm on the communication systems.

COMPUTER SIMULATION OF AN UNMANNED AERIAL VEHICLE
ELECTRIC PROPULSION SYSTEM
Joel Yourkowsky-Major, United States Marine Corps
B.S., United States Naval Academy, 1983
Master of Science in Electrical Engineering-March 1996
Advisor: Jovan E. Lebaric, Department of Electrical and Computer Engineering

There has been a substantial increase in the use of electric propulsion systems in Unmanned Aerial Vehicles (UAVs). However, this area of engineering has lacked the benefits of a dynamic model that could be used to optimize the design, configurations and flight profiles. The Naval Research Laboratory (NRL) has accurate models for the aerodynamics associated with UAVs. Therefore the proposed electric propulsion model would use the torque and RPM requirements generated by the aerodynamic model and provide an accurate representation of the desired UAV electric propulsion system. This thesis reports on the development of such a model. The model is adaptive in the sense that motor and battery parameters can be altered by the user to reflect systems currently in use or those considered for future systems. Not only will the simulation model accurately reflect the operating conditions of the motor and battery during the mission, but different flight profiles with the same configuration can be evaluated in terms of efficiency based on the Percent Battery Capacity Used (PBCU) at the end of the mission. This Electric Propulsion Simulator is part of a larger NRL project intended to design and deliver UAVs to the Naval Service over the next few years.

INITIAL DISTRIBUTION LIST

1.   Defense Technical Information Center   2
     8725 John J. Kingman Rd., STE 0944
     Ft. Belvoir, VA 22060-6218

2.   Dudley Knox Library, Code 013   2
     Naval Postgraduate School
     411 Dyer Rd.
     Monterey, CA 93943-5101

3.   Associate Provost and Dean of Research   2
     Code 09
     Naval Postgraduate School
     Monterey, CA 93943-5138

4.   Chair   5
     Department of Electrical and Computer Engineering
     Naval Postgraduate School
     Monterey, CA 93943-5000

5.   Associate Chair for Research   1
     Department of Electrical and Computer Engineering
     Naval Postgraduate School
     Monterey, CA 93943-5000

6.   Dean, Division of Science and Engineering   1
     Code 07
     Naval Postgraduate School
     Monterey, CA 93943-5000

7.   Provost and Academic Dean   1
     Code 01
     Naval Postgraduate School
     Monterey, CA 93943-5000